CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

Electronic Power Supply and Sensor Emulator for the CSUNSat1

A Project submitted in partial fulfillment of the requirements

For the degree of Master of Science

in Electrical Engineering

By

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December 2013

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ABSTRACT

Design of an Electronic Power Supply and Sensor Emulator for the CSUNSat1

By

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Master of Science in Electrical Engineering

A Cubesat is a miniature satellite which is launched into Low Earth Orbit, and has become quite popular amongst hobbyist and institutions. The size of the satellites and the complexity of the system as a whole make the projects very educational for students or any others who wish to further their knowledge in engineering. The CSUNSat1 is a Cubesat project taken on by California State University Northridge (CSUN), in collaboration with Jet Propulsion Laboratories (JPL).

The Electronic Power Supply and Sensor Emulator (EPSSE) serves the purpose of testing the CSUNSat1 system during the development stages. For example testing what would happen if for some reason the CubeSat processor loses power for an amount of time, or the temperature rises to a certain limit, how would the software be able to handle this problem and what would be the result.

To test the CSUNSat1 the voltage or current levels of a temperature or power supply must be simulated. Testing of electronic systems has in the past been accomplished using traditional tools like function generators. To test the CSUNSat1, a system has to be designed in order to simulate more than one signal, and should be easily configured by the user.

The EPSSE is a Graphical User's Interface (GUI) designed in software, and electronics which serve the purpose of realizing the user's test profile created in the GUI. The goal is to design a GUI which gives the

user an easy method of configuring a test, while offering the capability to fully test the CSUNSat1 microcontroller's software. The CSUNSat1 microcontroller software will be responsible for monitoring the currents and voltages of the power supply, various sensors, and the batteries under test.

The reason for designing a GUI based test system is due to the recent popularity of visually based test equipment, and the idea of carrying out long exhaustive test on a system that may take much longer to configure than to actually run the test. The GUI was designed in MATLAB and the electronics involve a microcontroller, a digital to analog converter, and miscellaneous components. The end product is essentially a programmable arbitrary waveform generator.

1 Introduction

This report is a description of the Electronic Power Supply and Sensor Emulator (EPSSE) test system designed to test the CSUNSat1 functionality. The report will give a background of test equipment, which will be followed by an in depth description of the EPSSE. Then followed by a tutorial on how to use the EPSSE. This report can serve as a user's manual or design report.

Traditionally test equipment is made per the design. The purpose of any test equipment is to test the functionality of the design. The main functions of the CSUNSat1 is to a) survive in low earth orbit (LEO), b) monitor the voltage and current levels of the payload, and c) transfer that information down to mission control (CSUN campus). The EPSSE will test the CSUNSat1's capability to measure the voltage and current levels of the payload.

Before moving on, it should be stated that when referring to a GUI action

Select = left mouse click of push button

2 Background

This test system will have the capability to simulate eight different sensors, or eight different voltages, or a combination of both. Therefore to start, a brief introduction as to what a sensor is or how to measure a physical characteristic is important. A sensor is a transducer, meaning a physical phenomenon is measured, such as pressure, temperature, etc, and converted into an electrical signal (voltage, or current). This electrical signal will change based on a change in the physical phenomenon. After the voltage is sampled and conditioned, this voltage will indicate a measurement. It is the duty of the electronic system to be able to condition, sample and compute the measurement.

To validate any electronic design, ensure it meets requirements a test system is built. This is most likely part of the design process. The idea behind test equipment is to simulate a voltage or current in order to validate the electronic system is working. To validate this many elaborate test systems and stations have been developed and implemented. The broadness of test system and cost of the test system is usually dependent on the requirements for the testing the system. These requirements are usually stipulated by the customer. The design of the test equipment is usually designed in parallel.

The need for test equipment has become so customary that a specific type of engineer (Test engineer) is one of the most sought out engineers in the field today. This specialized Engineer is responsible for testing and validating electronic components and designs [6].

Test equipment software and companies are now some of the biggest employers of young engineers, and LABVIEW (a common test equipment software and hardware company) equipment of some sort is in almost every engineering company's lab or office.

3 Overview

The requirements for the EPSSE are derived from the Requirements for CSUNSat1 Revision 1.1. The JPL experiment section 3.2.10 requires that the CSUNSat1 main processor shall use temperature, current, or voltage data from the experiment to control the timings, connections, charging magnitudes and discharging magnitudes of the experiment. Section 3.2.11 states the main processor shall protect the space craft from experiment faults. The main processor shall sample the voltages as a rate of 1Hz, which may vary between 0 – 5V +/-0.1V. There will be six voltages.

The EPSSE is a device which is composed of electronics, for creating voltage and current simulation, a GUI which allows the user to configure the desired simulation, and the software which serves the purpose of loading the electronics with the files configured in the GUI. The EPSSE simulator box will provide eight channels or signals and thus the GUI will involve configuring these 8 channels.

The EPSSE GUI was designed to test the CSUNSat1's ability to meet the requirements in the Requirements for CSUNSat1 Revision 1.1 document. The four design goals are as follows:

1. The EPSSE GUI is designed as to offer the user the most user friendly means of configuring a test or simulation.

2. The values calculated and stored are meant to output values thru the electronics which would range from 0 to 5.25 volts.

3. The values would be output at a rate of 10Hz or 1 sample every millisecond. This is faster than the required sample rate [7]. The max slew rate now set at 5.25V/mSec.

4. The test or simulation would be able to last long enough to test the ability of the processor to endure power loss during eclipse or loss of sunlight for some reason.

When the EPSSE is being utilized to test the CSUNSat1, the system configuration is that of figure 1. The system consists of two major hardware components. 1) A Personal Computer, and 2) The EPSSE Simulator Box. Inside the EPSSE box is all of the electronics hardware, and interconnections. The Host

PC is where the user will configure the test simulation, while the EPSSE Simulator Box contains the electronics needed to implement the simulation.

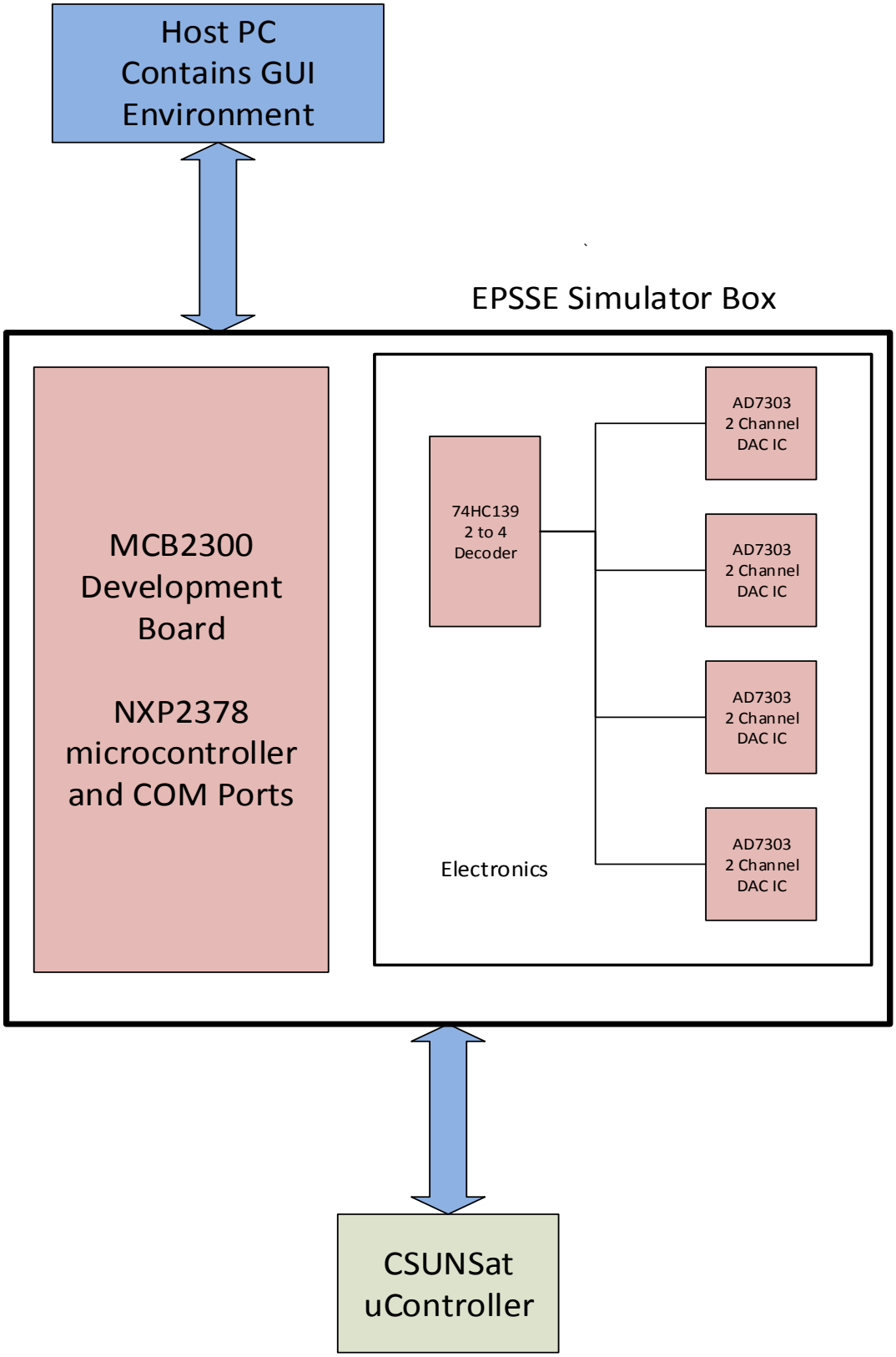


Figure 1: System Block Diagram

4 Electronics

The Electronics is composed of a microcontroller (NXP2378), contained on the MCB2300 development board. A digital to analog converter (DAC), a decoder, 4 AD7303 Analog Devices serial communication DAC's. The microcontroller is an NXP2378, which utilizes the ARM7 architecture. The MCB 2300 Development board contains various electronics [8] for programming the NXP2378, and for communicating with other devices. Two COM ports, have a UART communications protocol. One of these ports can be used with a serial to USB cable to program the NXP2378. The MCB2300 board contains an IC MAX563 UART to serial converter IC [9].

4.1 NXP 2378 Microcontroller

The NXP2378 is an ARM7TDMI-S microcontroller. The NXP2378 contains several peripherals (figure 2), but this paper will only cover in detail the peripherals and functions which are used. Refer to the UM10211 NXP23xx User's Manual for all peripherals and configuration. All peripherals are configured by setting bits in memory mapped registers. Each memory location contains one byte.

The NXP2378 has memory allocation for flash programming of 512KB. This accounts for 512KB of memory for the program, and the data which makes up the signals sent to the electronics. This was considered when deciding on the rate the values are sent to the CSUNSat1 main processor. Each value can be set at 8 bits, but this will allow 512KB-Program memory for the values. The hex file is 6KB this leaves 506KB for the values. That is 506,000 locations.

$$506{,}000 = 60\ (seconds) * 60\ (minutes) hours * 8\ (channels) * 10\ (samples\ per\ second)$$

Equation 1: Equation for Allocation of memory

Table 1: Max Hours of Simulation per Channel

Channels	Max (hours)
8	1.75
7	2
6	2.34
5	2.811
4	3.51
3	4.68
2	7.02
1	14.05

The max hours for each channel are shown in table 1.

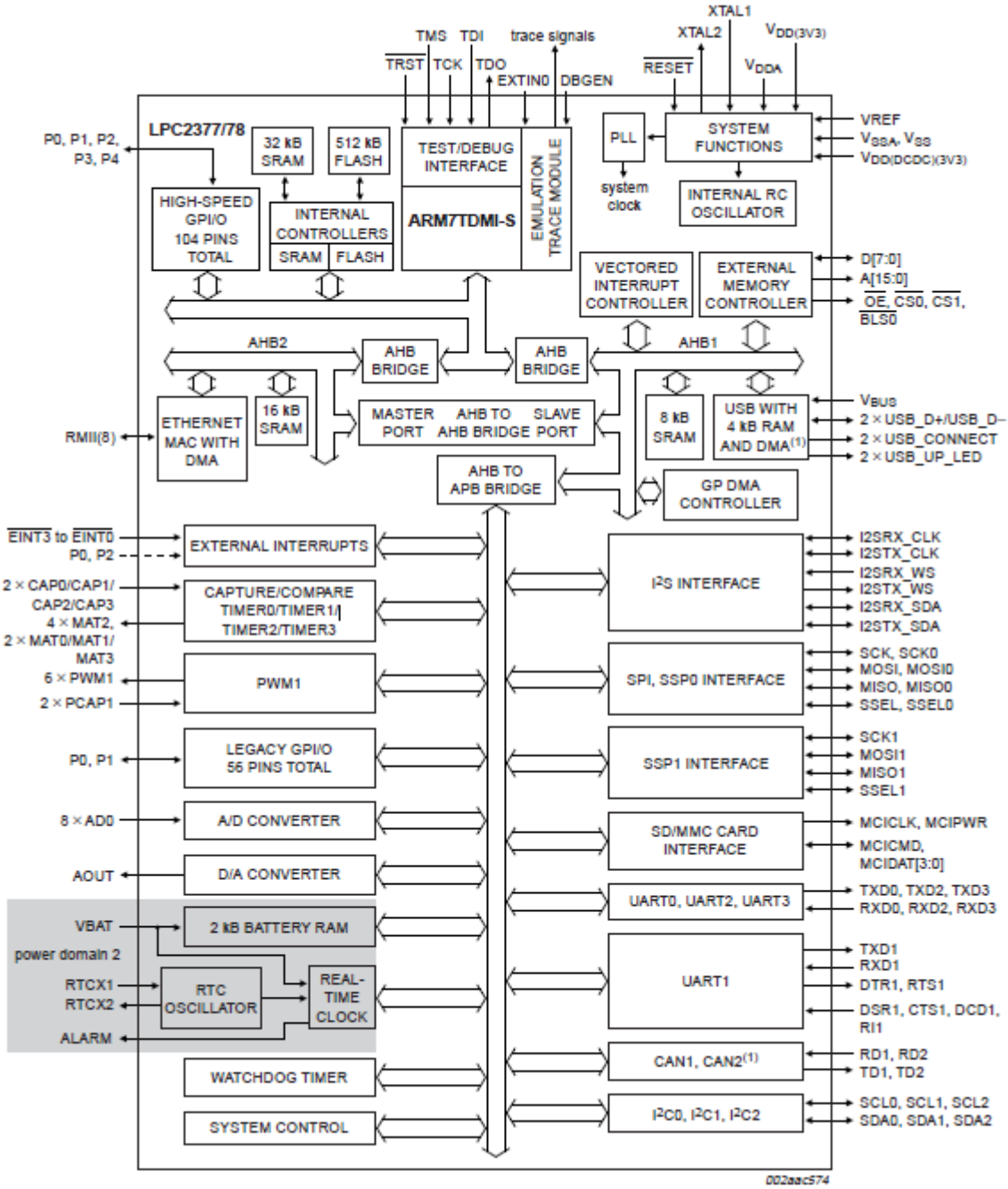


Figure 2: NXP2378 Block Diagram [1]

4.1.1 Serial Peripheral Interface (SPI)

The SPI is a full duplex synchronous serial communication protocol. Which means that data is sent out in sync with a clock, and data can be sent to and from on the same bus. As can be seen below the SCK is the master clock and depending on the configuration the data is clocked out on the rising or falling

edge of the SCK. The Slave Select (SSEL) line is an active low line, and must be asserted for the data to be received by the slave. This serves as a sort of handshaking for the two devices [3]. The SSEL line can be any signal which will can drive an output to be a low (below 0.8V, for CMOS), and does not have to be the specific SSEL line designated in the memory mapped IO.

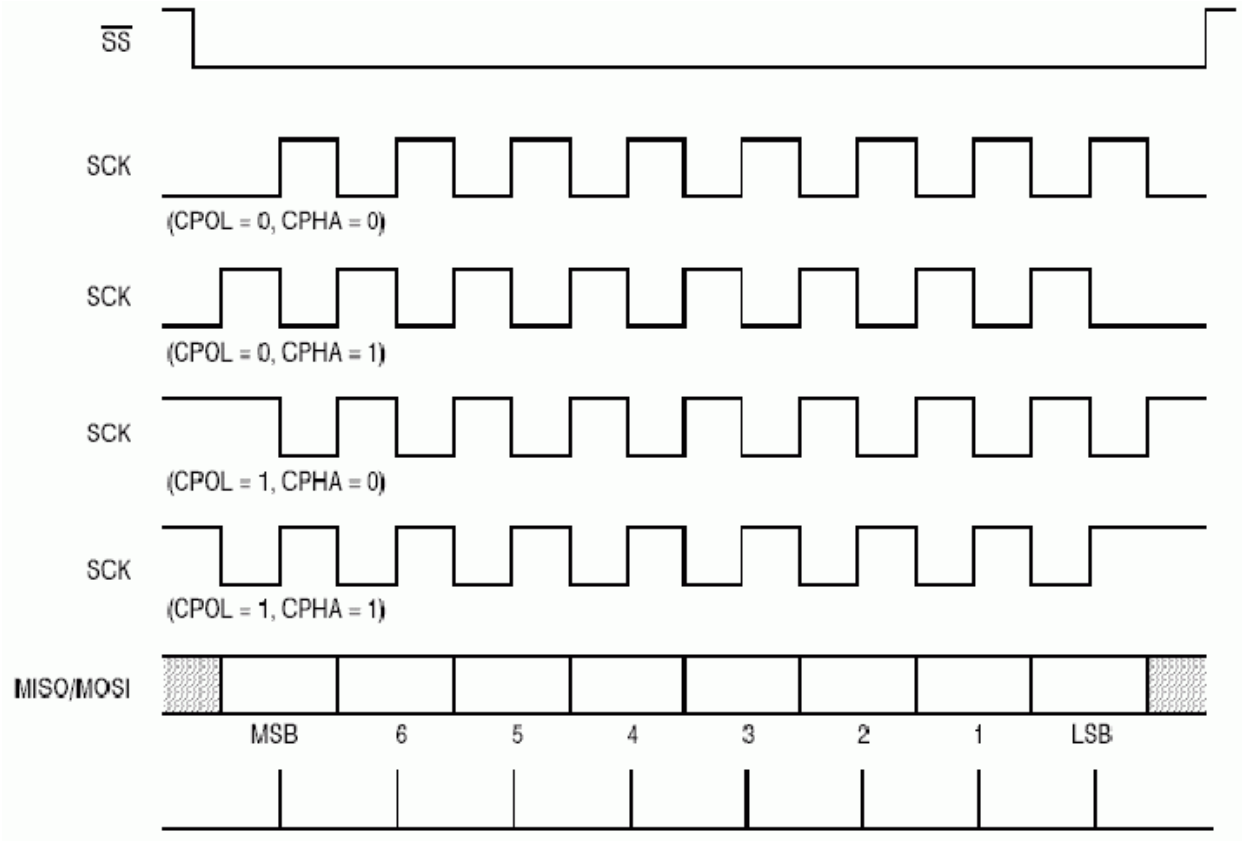


Figure 3: SPI Protocol

An SPI interface is configured using a master and a slave. The master has the responsibility of providing the clock. The SPI registers are memory mapped on the NXP2378, and communicate with the ARM7 microcontroller over the Advanced Peripheral Bus (APB).

4.1.1.1 Pin Description

The SPI interface uses 4 pins for interfacing with the other device. These pins are described in table 1.

Name	Type	Description
SCK	Input/output	Serial Clock. Clock sent out by the master if the NXP is configured as master, or input clock from device if NXP is configured as slave
SSEL	Input	Slave Select. The slave select line is a active low signal which is used to select a device for communication
MISO	Input/Output	Master In, Slave Out. If NXP is configured as master then this is the input from the slave device. If the NXP is a slave this is the oupt
MOSI	Input/Output	Master Out, Slave In. If NXP is configred as master this is the output, if NXP is a slave this is the input

Table 2: SPI Pin Description [1]

Note here that the SSEL line is an input, and this is because if the device is set as a slave, this line will be an input. As stated before if this line is an output then it can be used as a SSEL line, but does not have to be set to that in the PINSELx register.

4.1.1.2 Configuration Registers

The NXP2378 has five configuration registers (table 2).

Name	Description	Access	Address
SSPxCR0	SSP control register0	R/W	0xE0068000
SSpxCR1	SSP control register 1	R/W	0xE0068004
SSPxSR	SSP Status register	RO	0xE0068008
SSPxDR	SSP Data Register	R/W	0xE006800C
SSPxCPSR	SSP Clock counter register	R/W	0xE0068010

Table 3: SPI Registers [1]

The SPI control registers configures the operation of the SPI. The SPI can be configured to send anywhere from 8 bits in a single write up to 16 bits. The clock phase and polarity can be set to determine the relationship between the data being sent out and the clock. The SPI can send LSB first or MSB first, and interrupts can be enabled with the control register as well.

The Status Register is used to check the status of the transmission of receive operations. A read overrun indicates that the SPI read buffer contains data that has not been read by the processor, and new data has already arrived. A write collision will indicate that a write to the SPI data register was done before

the data has been sent. If the device is set as a master and the SSEL line goes low and is set as an SSEL line, then a mode fault will occur, stating that the device is configured as a master, but another device is treating it as a slave. SPI transfer complete will indicate that an SPI transfer has been completed. This bit is used to check when new data should be inserted into the SPI data register.

The SPI Data register is a 16 bit register which contains transmit or receive data. The upper 8 bits are the MSB's and the lower 8 bits are the LSB's. If the SPI is configured to send only 8 bits the lower 8 bits will contain the data sent.

The SPI Clock register controls the frequency of the master clock (SCK), and thus controls the frequency which data is sent out or received. In the Master mode this must be an even number greater or equal to 8. This register, along with the PCLK register will control the rate at which data is sent or received.

The SPI interrupt register can be used to generate an interrupt when a SPI transfer is complete, or there is a mode fault. Please refer to section 6.2 for the configuration for this project and the code which implements the configuration.

4.1.2 UART

The NXP2378 contains four UART interfaces. One of the UART interfaces is needed for download of application code, if JTAG is not used. Refer to section 9.1 for instructions of application code download.

UART1 will be utilized in this project for sending real time data to the Host PC. The host PC will contain a program which will plot in real time the data being sent to the CSUNSat1 processor. This will provide the user the ability to validate and observe the response the CSUNSat1 will have to the simulation.

4.1.2.1 UART 1 Configuration Registers

The NXP2378 contains fourteen registers for each of the four UART interfaces. The UART1 registers which are used for this project are described in table 3.

Name	Description	Access	Register
RBR	Receiver Buffer Register. Contains 8 bits of data	RO	0xE0010000
THR	Transmit Holding Register. Contains 8 bits of write data	WO	0xE0010000
DLL	Divisor Latch. 8 Least significant bits of divisor latch. Used to divide the PCLK for setting the desired Baud Rate. See Section 4.1.2.3 Setting Baud Rate	R/W	0xE0010000 (DLAB = 1)
DLM	Divisor Latch. 8 most significant bits of divisor latch		0xE0010004 (DLAB = 1)
IER	Interrupt Enable Register. Enables the Auto-Baud time-out interrupt	R/W	0xE0010004 (DLAB = 0)
IIR	Interrupt ID Register	RO	0xE0010008
FCR	FIFO Control Register. Reset the RX or RX FIFO , and enable FIFO	WO	0xE0010008
LCR	Line Control Register. Used to configure the word length, select 1 or 2 stop bits, enable parity, select parity type, break control, and divisor latch bit access	R/W	0xE00100C
LSR	Line Status Register. Indicates a Receiver data ready, overrun error, parity error, framing error, break interrupt, transmit holding register empty, transmit empty, and RX FIFO error	RO	0xE0010014
SCR	Scratch Pad Register. Readable and writable register	R/W	0xE001001C
ACR	Auto baud Control Register. Used to control Auto Baud functions.	R/W	0xE0010020
FDR	Fractional Divider Register. Used to setup the baud rate	R/W	0xE0010028
TER	Transmit Enable Register. Enables a transmit of the FIFO data	R/W	0xE0010030

Table 4: UART 1 Configuration Registers [1]

Notice that some registers are used for multiple purposes. This should be a caveat for the programmer when configuring the UART.

4.1.2.2 Baud Rate Calculation

The baud rate is configured using equation 2.

$$UARTbaudrate = PCLK/(16 * (256 * DLM + DLL) * \left(1 + \frac{AddVal}{MulVal}\right))$$

Equation 2: Baud rate Calculation [1]

PCLK – clock supplied to the UART.

DLM – Divide bits (upper)

DLL – Divide bits (lower)

AddVAL – the numerator for a fractional divide value

Mul Val – the denominator for a fractional divide value

4.1.2.3 UART Pin Description

Name	Type	Description
RXD1	Input	Serial Receive Data
TXD1	Output	Serial Transmit Data

Table 5: UART Pins [1]

4.1.3 Timer

The NXP2378 contains four timers which can be used for different purposes. For this project the Timer0 is utilized to implement a delay. The timer can be configured using the memory mapped registers outlined in Table 5. The Timer is a 32 bit counter and each of the four match registers per timer can be configured to cause an interrupt. The timer also contains external match registers which can be enabled to

set low, set high, or toggle upon a match condition. Please refer to section 6.4 for the application code which implements a delay for this project.

Name	Descriptoin	Access
IR	Interrupt Register. Using the VIC a write to the will clear the interrupt flag. This register can also be read if polling is being used.	R/W
TCR	Timer Counter Register. The TCR is used to control the timer functions	R/W
TC	Timer Counter. 32 bit register which increments every PR+1 cycle of the PCLK.	R/W
PR	Prescale Register. When the PC is equal to this value the TC is incremented and the PC is reset	R/W
PC	The Prescale Counter is a 32 bit value which increments on the PCLK	R/W
MCR	Match Control Register. Used to control if an interrupt is generated when the TC matches a MR	R/W
MR0	Match Register 0. Stores value which the TC will match, and genrate and interrupt, reseet TC, stop Timer or do nothing	R/W
MR1	Match Register 1	R/W
MR2	Match Register 2	R/W
MR3	Match Register 3	R/W
CCR	Capture Control Register. Controls which edges of the capture inputs are used to load the capture registers	R/W
CR0	Capture Register 0. Loaded with the value of TC, when a capture event occurs	RO
CR1	Capture Register 1	RO
EMR	External match registers. Controls the external match pins	R/W
CTCR	Count Control Register. Selection between timer or counter operation	R/W

Table 6: Timer Registers [1]

The timer does have pins for external match and capture functions, but due to the fact that the timer is being used as a delay, the pins are not configured and thus not used.

4.2 MAX 563 UART Controller

In order for the NXP2378 to communicate through UART, a UART controller is needed. The MAX53 contains 2 RS-232 drivers and 2 RS-232 receivers. This makes it ideal for the two UART ports which will be used (1 for the programmer, and 1 for the UART real time data sent to the host PC). This UART controller is present on the MCB2370 development board.

4.3 2 to 4 Decoder

A simple 2 to 4 decoder is used as a chip select for the four different DAC IC's. This will create 8 channels. The decoder is a 74HC139 2 to 4 decoder [4]. This decoder is an active low output. So a 0000 will set the 1st output low and all others high, a 0001 will set the 2nd output low and all others high. This decoder is used as the select line (SSEL) for the four DAC's, which is an active low enable. Therefore to enable the DAC1 a 0000 is sent to the decoder through GPIO pins on the NXP2378. Along with this and the two channels on the DAC's it provides five channels.

4.4 Digital to Analog Converter

For this project a DAC IC is used to send out voltages which can then be interpreted by the CSUNSat1 main processor. These voltages, as stated in the overview section represent the data the microcontroller would be receiving during its mission duration. The DAC IC is an Analog Devices, AD7303 [2]. This is a 2 channel DAC which is a full scale DAC, which is capable of communication through SPI protocol. The shift register is 16 bits wide, which are used to configure and set the output of each channel. The transfer function of the DAC is as follows:

$$Vout = 2 * Vref * (\frac{N}{256})$$

Equation 3: AD7303 Transfer Function

Where N is an eight bit hex value. For example

If Vref is set to Vdd/2, selected as internal reference.

$$Vout = 2 * 2.5 * \left(\frac{128}{256}\right) = 5 * \frac{1}{2} = 2.5V$$

With 5V for Vdd the max output is 5V. The AD7303 datasheet sets the max Vdd as 5.5V. Which will indicate that the max output of the AD7303 is 5.5V. For this project four AD7303's will be utilized to set up an eight channel configuration. The reference voltage will be selected as the internal reference and thus Vdd will be set to provide the CSUNSat1 main processor with the required voltage range stipulated in the requirements document. The Vdd will be supplied from the NXP2378 and will be 5.25 volts. This will provide the ability to output the voltage range specified in the initial design goals (2).

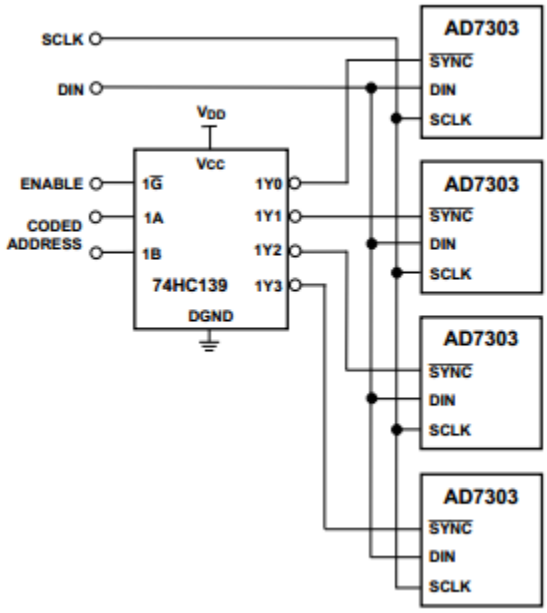


Figure 4:8 Channel DAC configuration [2]

As can be seen the SCLK and Data lines will all be the same, the only difference is the coded address which will cycle through the AD7303's and the Enable line, the decoder will only be enabled right before the serial data is being sent to the AD7303 device, as advised in the AD7303 datasheet [2].

The AD7303 architecture uses a shift register for the input control bits and data bits, and an input register.

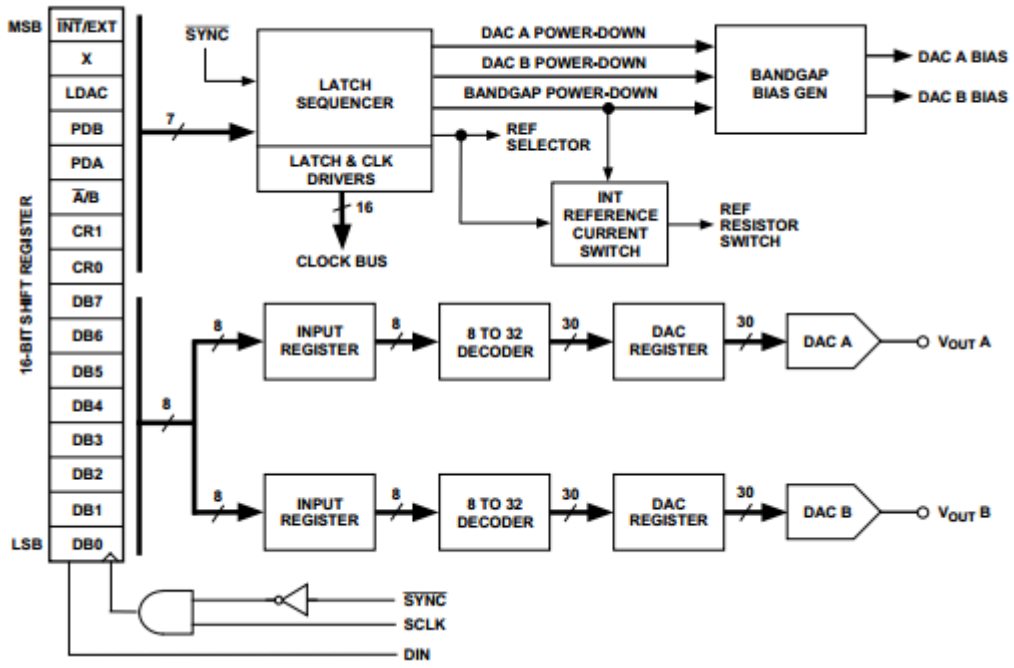


Figure 5:AD7303 Internal Logic [2]

Figure 5 shows that the control bits will set the functionality of the device, while the data bits flow dependent on the control bits.

DB15 (MSB)															DB0 (LSB)
INT/EXT	X	LDAC	PDB	PBA	A/B	CR1	CR0	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Control Bits								Data Bits							

The input shift register contents indicate as stated before that the upper 8 bits are control bits, and the lower 8 bits are data bits. Bit 15 selects between internal or external reference. For this project the internal reference is selected which is Vdd/2. Bit 14 is a don't care bit. Bit 13 is a load DAC bit, its purpose is to load the DAC registers for a synchronous update. The PDB bit is a power down DAC B bit, and PDA is a power down DAC A bit. Neither are powered down during the simulation. The A/B bit is used to select between DAC A and DAC B and with CR1 and CR0, really control how data is loaded into the DAC registers and how data is sent out of the device.

CONTROL BITS

LDAC	$\overline{A}$/B	CR1	CR0	Function Implemented
0	X	0	0	Both DAC registers loaded from shift register.
0	0	0	1	Update DAC A input register from shift register.
0	1	0	1	Update DAC B input register from shift register.
0	0	1	0	Update DAC A DAC register from input register.
0	1	1	0	Update DAC B DAC register from input register.
0	0	1	1	Update DAC A DAC register from shift register.
0	1	1	1	Update DAC B DAC register from shift register.
1	0	X	X	Load DAC A input register from shift register and update both DAC A and DAC B DAC registers.
1	1	X	X	Load DAC B input register from shift register and update both DAC A and DAC B DAC registers outputs.

Figure 6: AD7303 Truth Table [2]

As can be seen in figure 6there are a number of combinations. For this project if DAC A is to be used then the Control bits are set to 0x3, which will set DAC A DAC register to be updated from the shift register and then the data will be sent out immediately. For DAC B 0x7, will do the same, and thus is what is configured in the software.

5 MATLAB GUI

The GUI for this project was designed in MATLAB. This is due to a couple of reasons, none taking precedence over the other.

1. MATLAB is a familiar tool for most of the current Electrical Engineering students. If this project is to be modified at any time in the future, the tools would be available.

2. MATLAB tools for creating a GUI are intuitive and the built in functions included in the library allow less of a learning curve.

3. MATLAB's popularity is the reason for a bevy of information and tutorials.

MATLAB uses what is called "guide" (figure 8), to design the GUI visually. To implement a function simply drag and drop from the options on the left and then resize and position as desired. Each time a widget (pushbutton, text box, plot, etc.) is created, a callback function is created in an m-file. This m-file can be edited to implement the functions and task which you would like the GUI to accomplish. Once the design is finished then select the play button and the m-file is created. The GUI can be updated as desired by opening the fig file, or editing the m-file. For a more complete tutorial on MATLAB guide and GUI design please refer to [5].

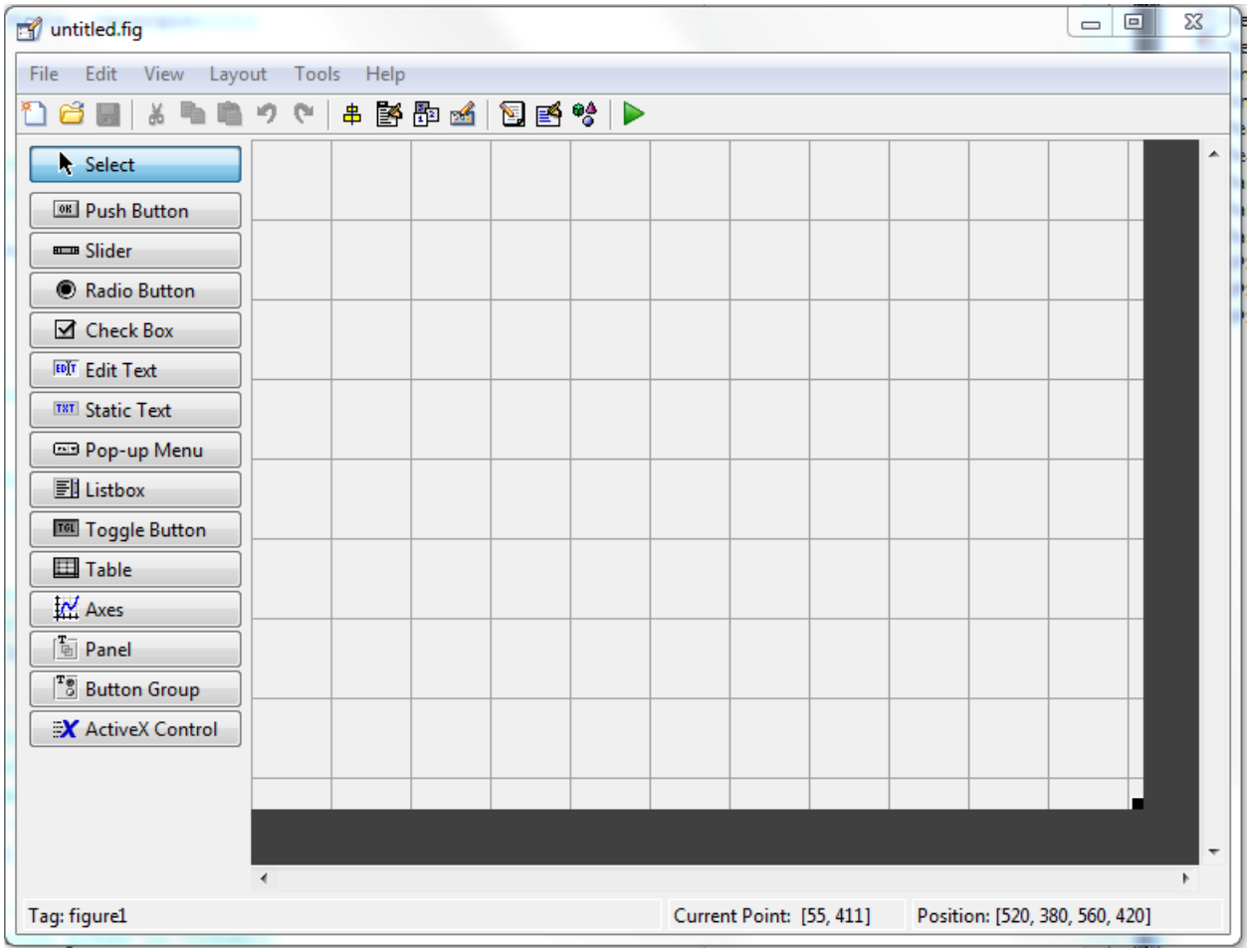


Figure 7: MATLAB guide Blank figure

5.1 EPSSE

The EPSSE GUI is responsible for creating the values that will be loaded into the NXP2378 microcontroller memory. More specifically the values that will represent the voltages. These are hex values ranging from 0 (0V) to 0x255 (2Vref or Vdd). As stated the GUI was designed in MATLAB, and the goal of the software, is to provide the user the ability to set up a test or simulation without exiting the GUI. The Data Loader Software will serve the purpose of configuring the NXP2378, and sending the data. The details of the Data Loader Software will be described in section 6.

The EPSSE Main GUI is the first GUI which starts when the program is started. This GUI provides the main screen for the user to design the simulation. The design procedure is described in the User' Manual (section 9.3). Although different user's will configure different tests differently.

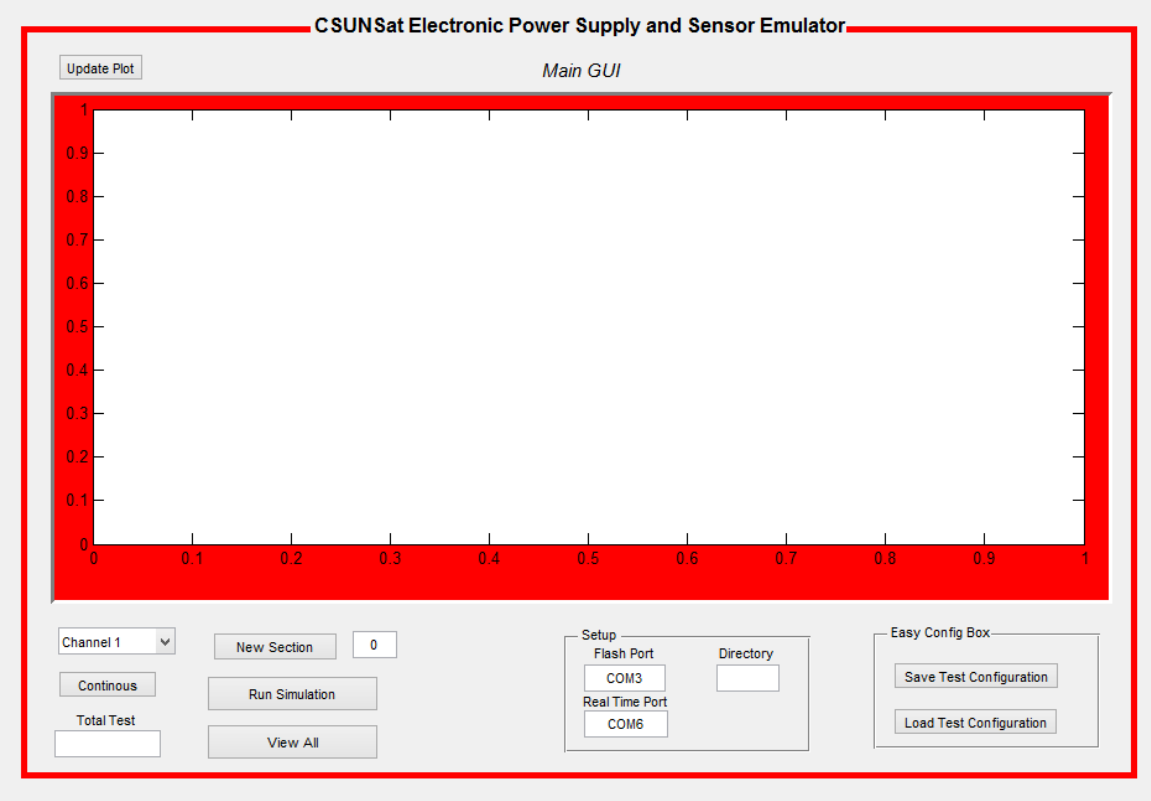


Figure 6: EPSSE Main GUI

5.1.1 Channel Select

The Channel Select is a dropdown menu which will select the current channel to display.

5.1.1.1 Function

Once a channel has been selected the display will display the current signal designed for that channel. If the signal for that particular channel has not been designed the display will be empty.

5.1.1.2 Implementation

The following code creates the Channel Select Function. Once the function is created the object string is set to display Channel 1, Channel 2….to Channel 8. This is implemented using the set function for that object.

% --- Executes during object creation, after setting all properties.

function ChannelSelect_CreateFcn(hObject, eventdata, handles)

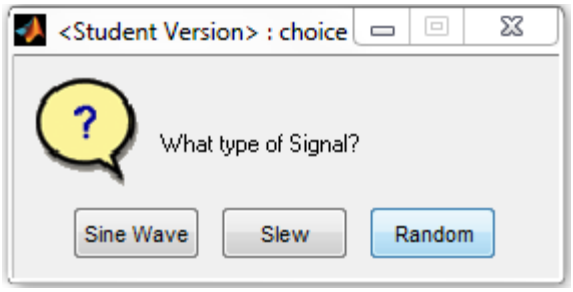
```
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
set(hObject,'String',{'Channel 1','Channel 2',...
    'Channel 3','Channel 4','Channel 5',...
    'Channel 6','Channel 7','Channel 8'});
```

5.1.2 New Section

The New Section button is located to the right of the Channel Select dropdown menu, and is a push button.

5.1.2.1Function

The function of the New Section button is to call a dialog message; this dialog message will prompt the user to choose what type (Sine Wave, Random, Slew) of new signal the next section or first section will be. Once the button is pressed it will also increment the New Section number.



5.1.2.2 Implementation

The NewSection Callback opens a question dialog and prompts the user to select. A function was designed to set NewSection implementing a switch statement. Depending on the statement selected a specific GUI will start which will give the user the options to select the parameters. The NewSection data

is then set as an object to pass to the GUI which will be opened. This is done with the setappdata MATLAB function.

```
% --- Executes on button press in NewSection.
%opens dialog box and updates section number
function NewSection_Callback(hObject, eventdata, handles)

   NewSection = handles.NewSection;

   chioce = questdlg('What type of Signal?',...
      'choice','Sine Wave','Slew', 'Random','Random');
   NewSection = setNewSection(chioce,NewSection);
   handles.NewSection = NewSection;
   set(handles.SectionNumber,'String',NewSection);
   guidata(hObject,handles);

   %make data avaiable for Section_Plot GUI
   hMainGui = getappdata(0, 'hMainGui');
   setappdata(hMainGui,'NewSection',NewSection);

%-------------------------------------------------------------
%setNewSection set the new section GUI based on the user input
%if a new plot is created then increment NewSection Number
%else keep it the same
%-------------------------------------------------------------
function [NewSection] = setNewSection( x , NewSection )

switch x
   case 'Sine Wave'
```

```
        run('Sine_Wave');
        NewSection = NewSection+1;

    case 'Slew'
        run('Slew');
        NewSection = NewSection+1;

    case 'Random'
        run('Random');
        NewSection = NewSection+1;

    otherwise
        NewSection = NewSection;
end
```

In MATLAB the Switch or Case statement syntax is different from C, an Otherwise is used to set the default condition. As can be seen if the user selects any of the options, then the NewSection variable will be updated, if not then the default condition is to leave the variable as it was before. This is important because the variable NewSection is used to pass arguments back and forth between the GUI's.

5.1.3 Run Simulation

The Run Simulation is a push button which should be used once the final signal for all channels has been created.

5.1.3.1Function

The function of Run Simulation is to do run three main tasks. The first is to create or update all of the signal files that are for the Data Loader software. These are .h files, and are includes which contain information about the signals timing, duration and parameters. Second is to start the build process, and download of the software into the microcontroller. This will be done by starting a batch file, which is

created and stored in the file system. This file should not be modified. Third is to start the real time plot in MATLAB, which will plot the data in real time as the signals are being sent out to the electronics the signals are also being brought into the Host PC by way of UART, which is sampled and plotted.

5.1.3.2 Implementation

```
433     % --- Executes on button press in RunSimulation.
434     function RunSimulation_Callback(hObject, eventdata, handles)
435     %find longest signal
436     %pad zeros onto other signals
437 -   lengths = [length(handles.u1) length(handles.u2) length(handles.u3)...
438         length(handles.u4) length(handles.u5) length(handles.u6) ...
439         length(handles.u7) length(handles.u8)];
440
441 -   handles.u1 = [handles.u1 zeros(1, (max(lengths)-length(handles.u1)))];
442 -   handles.u2 = [handles.u2 zeros(1, (max(lengths)-length(handles.u2)))];
443 -   handles.u3 = [handles.u3 zeros(1, (max(lengths)-length(handles.u3)))];
444 -   handles.u4 = [handles.u4 zeros(1, (max(lengths)-length(handles.u4)))];
445 -   handles.u5 = [handles.u5 zeros(1, (max(lengths)-length(handles.u5)))];
446 -   handles.u6 = [handles.u6 zeros(1, (max(lengths)-length(handles.u6)))];
447 -   handles.u7 = [handles.u7 zeros(1, (max(lengths)-length(handles.u7)))];
448 -   handles.u8 = [handles.u8 zeros(1, (max(lengths)-length(handles.u8)))];
449
450     %make the file
451     %channel 1 (IC1, channel A): code - 00 (IC1), control 0x3 (channel A)
452 -      file = fopen('I:\Graduate Project\Data Loader\Signal Files\signal_1.c','w');
453 -      make_file(1,file,handles.u1);
454 -      fclose(file);
455
```

When the code is run on the electronics, it is important to set how long the simulation will run. The length should be set to the longest signal created. For example if a sine wave is created on channel 1 that is 10 seconds, and a random signal is created on channel 2 which is 5 seconds, then the simulation should run for 10 seconds, and then repeat or end. This is the purpose of lines 437 to 448. The lengths of each signal will be put in a vector, and then the max length will be put in a vector and then the max of that vector will be used to pad the other signals with zeros.

Then the code will first open a file and name that file. Note this should be in the same location as the included c file in the Data Loader Software. This is done for all channels. The function make_file is used to make a c file with an array of values. These values are the values that will be sent out on the serial data line to the DAC IC's.

```
function make_file(ch,file,code,control,signal)

    [signal_hex] = convert_hex(signal);
    fprintf(file,'\n');
    fprintf(file,'/* Data Loader File */\n');
    fprintf(file,'char Signal_%d[] = {',ch);
    for i = 1:length(signal)
        fprintf(file,'0x%s%s,',signal_hex(i,1),signal_hex(i,2));
    end
    fprintf(file,'};\n');
```

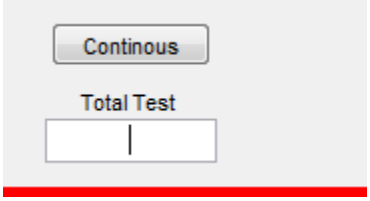
The function will call a function which is convert_hex, that will pass the variable signal, and return the signal_hex variable. The purpose of this function is to convert the signal vector to a hex value, which is what the DAC needs for a proper output. Once the signal is returned the rest of the function creates a file and the signal array for each channel. The control and code bits for each channel are hard coded.

```
533     %converts the signal to a hex value
534     function [signal_hex] = convertHex(signal)
535
536 -   q = quantizer('ufixed',[8 0]);
537 -   N = (signal*256)/5.25;
538 -   Level = 0.0343;
539 -   N = Level*round(N/Level);
540 -   signal_hex = num2hex(q,N);
```

The convert_hex function converts the value the value based on the transfer function of the AD7303 (Equation 2).

```
517    % toggle button set if simulation will run continously
518    % set the length
519 -        if(get(handles.togglebutton1,'Value'))
520 -            file = fopen('I:\Graduate Project\Data Loader\Signal Files\define.h','w');
521 -            fprintf(file,'#define forever');
522 -            fprintf(file,'\n');
523 -            fprintf(file,'#define length %d',max(lengths));
524 -            fclose(file);
525 -        else
526 -            file = fopen('I:\Graduate Project\Data Loader\Signal Files\define.h','w');
527 -            fprintf(file,'#define duration %d\n',handles.testDuration);
528 -            fprintf(file,'#define length %d\n',max(lengths));
529 -            fclose(file);
530 -        end
531
532    %build and download to Controller
533 -     start();
534    %monitor the signals in real time
535 -     run('Real_Time_Plot');
536
```

The end of the code in this function will get the value of the togglebutton1, this is the continuous button. The test will run until power is cut or there is some sort of fault. The Total Test Input box will set the number of times through the set of signals. The default is set to 1.



5.1.4 View All

View All is a push button which allows the user an option to observe all of the signals. This can be of use when the user has created a signal, but does not remember what the signal for a specific channel might be. This can also give the user a representation of the signals once the design has been created.

5.1.4.1 Function

As stated in the introduction, this feature simply plots all of the signals on one widget.

5.1.4.2 Implementation

To implement this code a simple subplot is created.

```
%--------------------------------------------------------------------
% --- Executes on button press in ViewAll.
%shows a plot of all of the Channels which have been created
%--------------------------------------------------------------------
function ViewAll_Callback(hObject, eventdata, handles)
    figure(1)

    subplot(4,2,1);
    plot(handles.n1,handles.u1);
    title('Channel 1');

    subplot(4,2,2)
    plot(handles.n2,handles.u2);
    title('Channel 2');

    subplot(4,2,3)
    plot(handles.n3,handles.u3);
    title('Channel 3');

    subplot(4,2,4)
    plot(handles.n4,handles.u4);
    title('Channel 4');

    subplot(4,2,5)
    plot(handles.n5,handles.u5);
    title('Channel 5');
```

```
subplot(4,2,6)

plot(handles.n6,handles.u6);

title('Channel 6');


subplot(4,2,7)

plot(handles.n7,handles.u7);

title('Channel 7');


subplot(4,2,8)

plot(handles.n8,handles.u8);

title('Channel 8');
```

5.1.5 Save Configuration

The save configuration is a button that will save the current test configuration. Once the button is selected then a pop up will prompt the user to save the file and in the desired location

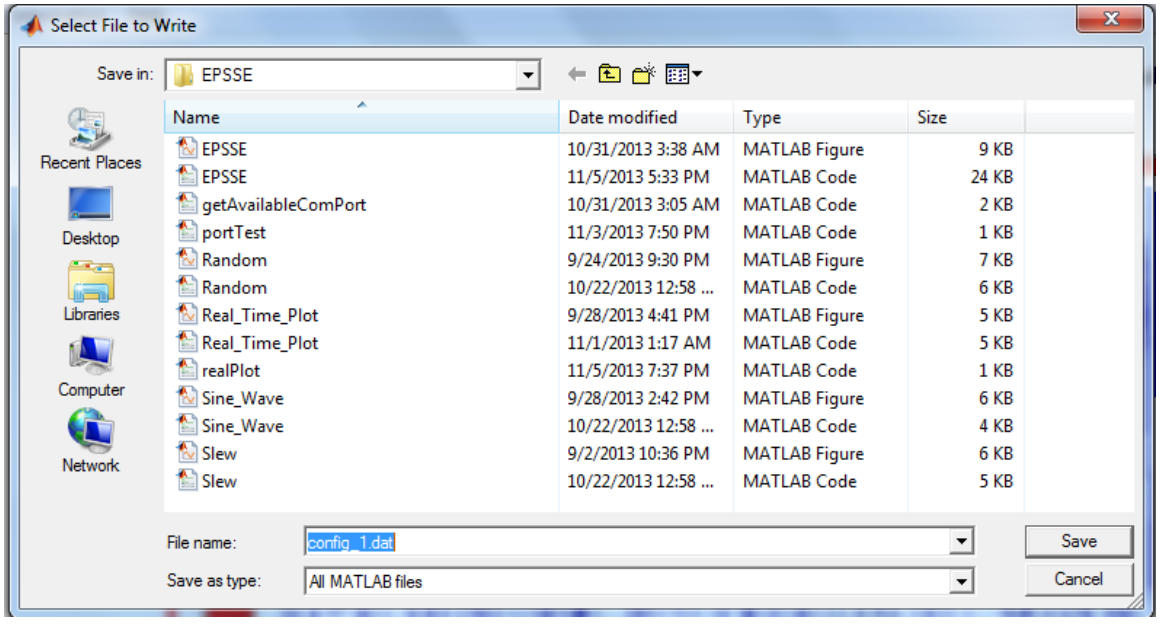

Select File to Write
Save in:
EPSSE
Recent Places
Desktop
Libraries
Computer
Network
Name
Date modified
Type
Size
EPSSE 10/31/2013 3:38 AM MATLAB Figure 9 KB
EPSSE 11/5/2013 5:33 PM MATLAB Code 24 KB
getAvailableComPort 10/31/2013 3:05 AM MATLAB Code 2 KB
portTest 11/3/2013 7:50 PM MATLAB Code 1 KB
Random 9/24/2013 9:30 PM MATLAB Figure 7 KB
Random 10/22/2013 12:58 ... MATLAB Code 6 KB
Real_Time_Plot 9/28/2013 4:41 PM MATLAB Figure 5 KB
Real_Time_Plot 11/1/2013 1:17 AM MATLAB Code 5 KB
realPlot 11/5/2013 7:37 PM MATLAB Code 1 KB
Sine_Wave 9/28/2013 2:42 PM MATLAB Figure 6 KB
Sine_Wave 10/22/2013 12:58 ... MATLAB Code 4 KB
Slew 9/2/2013 10:36 PM MATLAB Figure 6 KB
Slew 10/22/2013 12:58 ... MATLAB Code 5 KB
File name:
config_1.dat
Save as type:
All MATLAB files
Save
Cancel

Figure 7: Save Configuration Prompt

The file should be saved as a .dat file.

5.1.5.1Function

The function of this push button is to give the user a way to configure a test without designing all of the signals again, if for some reason the test has been aborted, or some other issue arises.

5.1.5.2 Implementation

To implement this function the MATLAB functions uiputfile, fwrite, fopen and fclose are used. Uiputfile is a function that will open the user input prompt for the user to save the file and in a specific location. The fwrite function writes data to a dat, or bin file (dependent upon the user). Fopen and fclose functions simpliy open and close documents in the Host PC, fopen is used to open the file with writer permission only. This is done so that no data is somehow read from the file. The fwrite in this case first will write the length of the signal to the file as an unsigned integer (uint32), and then write the rest of the data as a 64 bit floating point number (single).

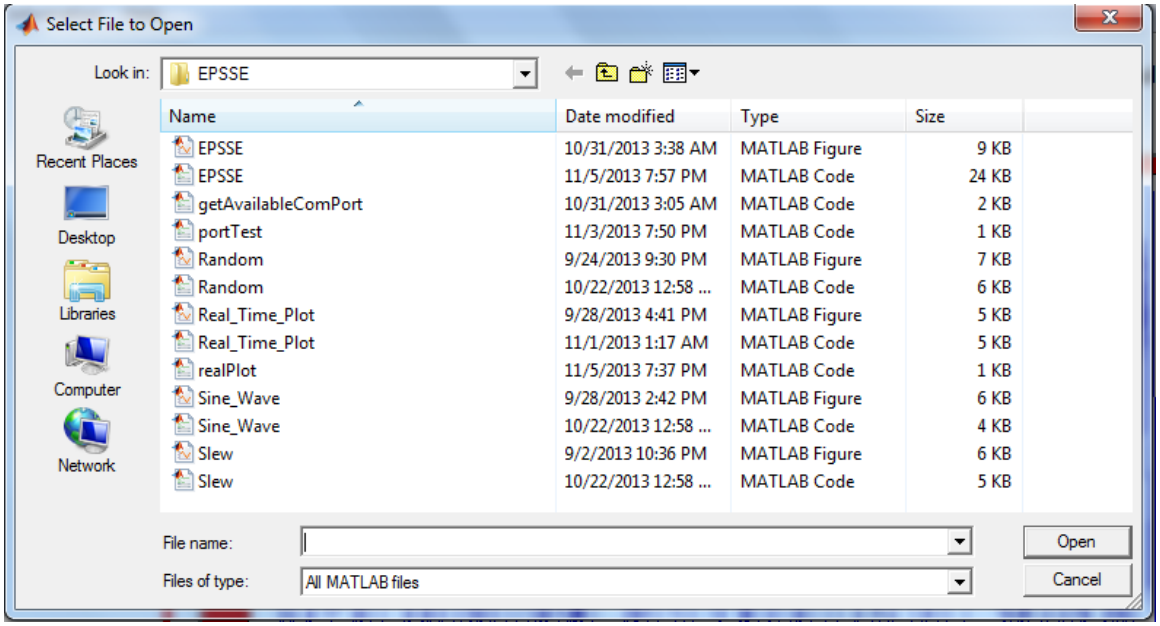
```
% --- Executes on button press in saveTestConfig.
% saves design to FileName
function saveTestConfig_Callback(hObject, eventdata, handles)

[FileName,PathName] = uiputfile;
saveFile = fopen(FileName,'w');
fwrite(saveFile,length(handles.u1),'uint32');
fwrite(saveFile,handles.u1,'single');
fwrite(saveFile,length(handles.u2),'uint32');
fwrite(saveFile,handles.u2,'single');
fwrite(saveFile,length(handles.u3),'uint32');
fwrite(saveFile,handles.u3,'single');
fwrite(saveFile,length(handles.u4),'uint32');
fwrite(saveFile,handles.u4,'single');
fwrite(saveFile,length(handles.u5),'uint32');
fwrite(saveFile,handles.u5,'single');
fwrite(saveFile,length(handles.u6),'uint32');
fwrite(saveFile,handles.u6,'single');
fwrite(saveFile,length(handles.u7),'uint32');
fwrite(saveFile,handles.u7,'single');
fwrite(saveFile,length(handles.u8),'uint32');
fwrite(saveFile,handles.u8,'single');
fclose(saveFile);
```

Figure 8: saveTestConfig Callback

5.1.6 Load Configuration

The Load Configuration push button will prompt the user to load a .dat file, which was created before and saved.


Select File to Open
Look in:
EPSSE
Recent Places
Desktop
Libraries
Computer
Network
Name
Date modified
Type
Size
EPSSE 10/31/2013 3:38 AM MATLAB Figure 9 KB
EPSSE 11/5/2013 7:57 PM MATLAB Code 24 KB
getAvailableComPort 10/31/2013 3:05 AM MATLAB Code 2 KB
portTest 11/3/2013 7:50 PM MATLAB Code 1 KB
Random 9/24/2013 9:30 PM MATLAB Figure 7 KB
Random 10/22/2013 12:58 ... MATLAB Code 6 KB
Real_Time_Plot 9/28/2013 4:41 PM MATLAB Figure 5 KB
Real_Time_Plot 11/1/2013 1:17 AM MATLAB Code 5 KB
realPlot 11/5/2013 7:37 PM MATLAB Code 1 KB
Sine_Wave 9/28/2013 2:42 PM MATLAB Figure 6 KB
Sine_Wave 10/22/2013 12:58 ... MATLAB Code 4 KB
Slew 9/2/2013 10:36 PM MATLAB Figure 6 KB
Slew 10/22/2013 12:58 ... MATLAB Code 5 KB
File name:
Files of type:
All MATLAB files
Open
Cancel

5.1.6.1 Function

This is used in conjunction with the Save Configuration push button. The user can load previously saved files once this button is pressed and use those previous configurations to quickly set up the test, thus reducing the time to gather more important data.

5.1.6.2 Implementation

The loadTestConfig callback function will open a prompt with the uigetfile MATLAB function. The file will be opened with read only permission. A for loop is set up to set the length of each file by reading the first unsigned integer value. The fseek function will go to the location of the first value, and then fread will read all of the values and store each in an array signified by u(I,:).

```
% --- Executes on button press in loadTestConfig.
% Loads a .dat file into the design
function loadTestConfig_Callback(hObject, eventdata, handles)
sampleRate = 1/1000;
fileName = uigetfile
file = fopen(sprintf(fileName),'r')
sum = 0;

for i = 1:8;
length(i) = fread(file,1,'uint32');
fseek(file,(sum*4)+4*i,'bof');
u(i,:) = fread(file,length(i),'single')';
sum = sum+length(i);
end

handles.u1 = u(1,:);
handles.u2 = u(2,:);
handles.u3 = u(3,:);
handles.u4 = u(4,:);
handles.u5 = u(5,:);
handles.u6 = u(6,:);
handles.u7 = u(7,:);
handles.u8 = u(8,:);

handles.n1 = 0:sampleRate:(length(1)/1000)-sampleRate;
handles.n2 = 0:sampleRate:(length(2)/1000)-sampleRate;
handles.n3 = 0:sampleRate:(length(3)/1000)-sampleRate;
handles.n4 = 0:sampleRate:(length(4)/1000)-sampleRate;
handles.n5 = 0:sampleRate:(length(5)/1000)-sampleRate;
handles.n6 = 0:sampleRate:(length(6)/1000)-sampleRate;
handles.n7 = 0:sampleRate:(length(7)/1000)-sampleRate;
handles.n8 = 0:sampleRate:(length(8)/1000)-sampleRate;
```

Figure 9: loadTestConfig Callback

5.1.7 Update Plot

The Update Plot push button is located at the top left of the GUI.

5.1.7.1 Function

The Update Plot button will plot a matrix of u(n) on the y axis with n(n) on the x axis, with n ranging from 1 to the number of channels. The plot will depend on the selection of the Channel. In programming language this is a switch statement with cases ranging from 1 to number of channels.

For Example, if there are four channels, then there are four different cases, and the syntax in MATLAB is

Switch variable

Case 1

Implementation for variable = 1

Case 2

Implementation for variable = 2

.

.

.

Case 4

Implementation for variable = 4

For this design the variable is Channel, which is the value from the ChannelSelect handle. This can be obtained from

```
Channel = get(handles.ChannelSelect,'Value');
```

This line of code uses the get function to grab a value in the handles structure. Here handles is a structure of data for the call back. The get function in MATLAB is similar to the get function using C++ in which the data is private and to access that data a function to get the data must be used. This is a technique called

data hiding or data abstraction. This is a feature that makes MATLAB so useful, in that when this is created the Callback function automatically creates this structure and the get and set functions are built in to the library.

Once the case has been met, then the implementation will clear the plot, compute the sample rate, and compute the signal. The sample rate for this project was chosen to be 1KHz. This should be more than enough to provide proper testing.

After the proper data has been created the data will be plotted, saved and made available to the rest of the functions in the GUI. The data is made available so that it may be plotted if a View All button is pressed or if the Channel Select is changed back to a channel that has already been designed.

5.1.7.2 Implentation

```
switch Channel
    case 1

        axes(handles.axes1);
        cla;
        sample_rate = 1/10;
        hMainGui = getappdata(0,'hMainGui');
        Duration1 = getDuration(getappdata(hMainGui,'Duration_1'));
        Duration2 = getDuration(getappdata(hMainGui,'Duration_2'));
        Duration3 = getDuration(getappdata(hMainGui,'Duration_3'));
        Duration4 = getDuration(getappdata(hMainGui,'Duration_4'));
        Duration = Duration1 + Duration2 + Duration3 + Duration4;
        n1 = 0:sample_rate:Duration-sample_rate;
        u1 = ([getappdata(hMainGui,'Signal_1'), getappdata(hMainGui,'Signal_2')...
            getappdata(hMainGui,'Signal_3'),getappdata(hMainGui,'Signal_4')]);
        handles.u1 = u1;
        handles.n1 = n1;
        guidata(hObject,handles);
        plot(handles.n1,handles.u1);
```

Figure 10: UpdatePlot_Callback

Figure 7 is just part of this callback, but the rest of the switch is identical except for the return values and the handles which are created. The Value of ChannelSelect will first be acquired and then based on that value the correct data will be plotted and saved to the correct handles. For example if the Channel Select has a value of 1, indicating Channel 1 is selected once the ”Update Plot” button is selected the n1, and u1 will be created and plotted. The variable n1 is referring to the number of samples which will be taken, if the duration is 2 seconds then the value of n1 should be 10*2 due to a sample rate of 10Hz. The function getDuration will grab data from all of the other GUI’s (Sine_Wave, Random, and Slew), if the data exist, if not then this data is set to 0. If the data was not set to 0, then the function would not run and the sequence of operations would stop. The variable u1, is a vectored array of all the signals that are created. Thus the reason for incrementing the “New Section” number.

```
%returns n which is a length
%sets the duraton of the plot
function [Duration] = getDuration(appdata)

    if(isempty(appdata))
        Duration = 0;
    else
        Duration = appdata;
    end
```

Figure 11: getDuration Function

5.2 Sine Wave GUI

Once the New Section push button is selected a question box will appear, this box will prompt the user to select which type of wave form the user would like to design. This is a starting point. The idea behind this is to give the user the ability to customize the test. For example it may be desired to test the nominal case for a period of time, and then for one minute or so go out of the nominal range. For this reason three different types of waveforms can be selected as a starting point.

If a sine wave is selected then, the Sine Wave GUI is opened.

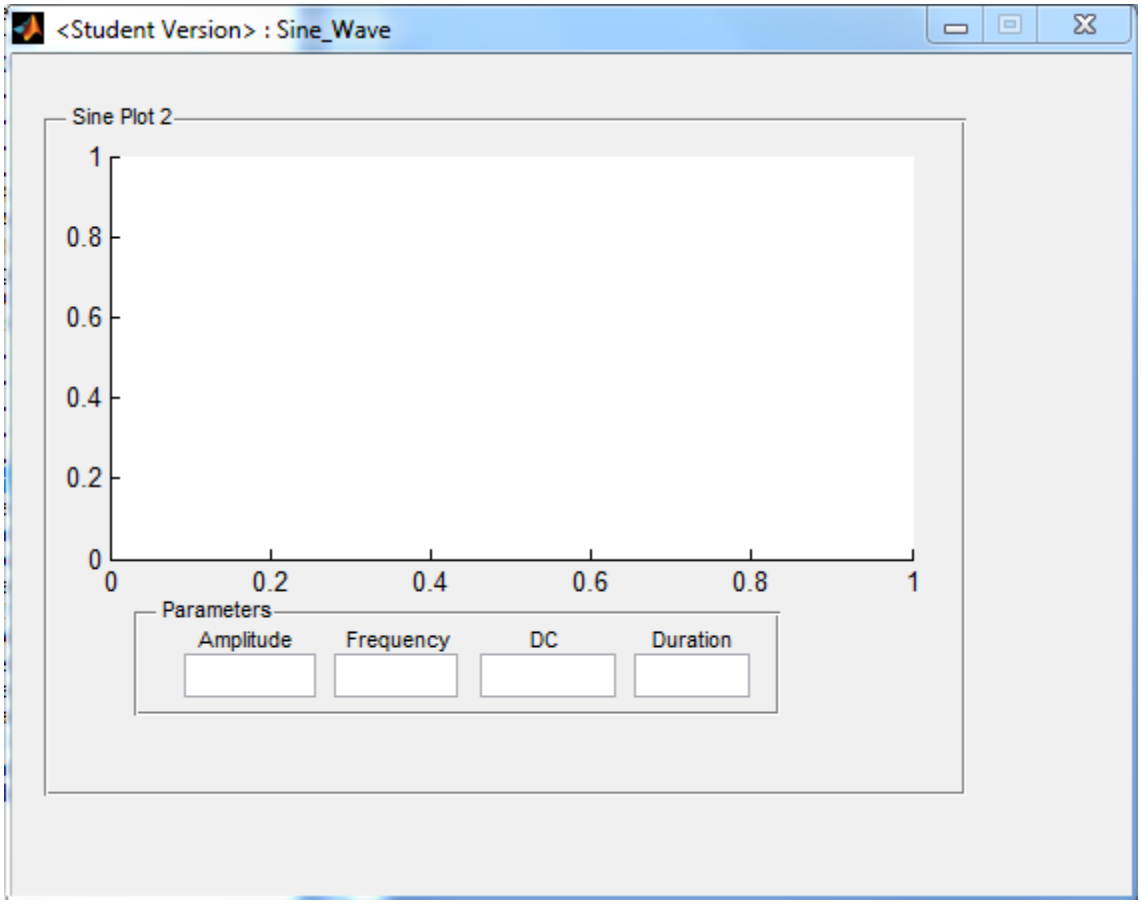


Figure 12: Sine Wave GUI

Observing figure 12, the Sine Wave GUI will open with a simple plot and parameters to customize the waveform. The amplitude is half of the peak to peak value. The frequency is in cycles per second, the DC box provides a DC offset for the signal and the Duration is the duration of the signal in seconds.

To create the sine wave with a peak to peak amplitude of four, a frequency of two and a DC offset of four, for duration of one second. Simply enter in the values.

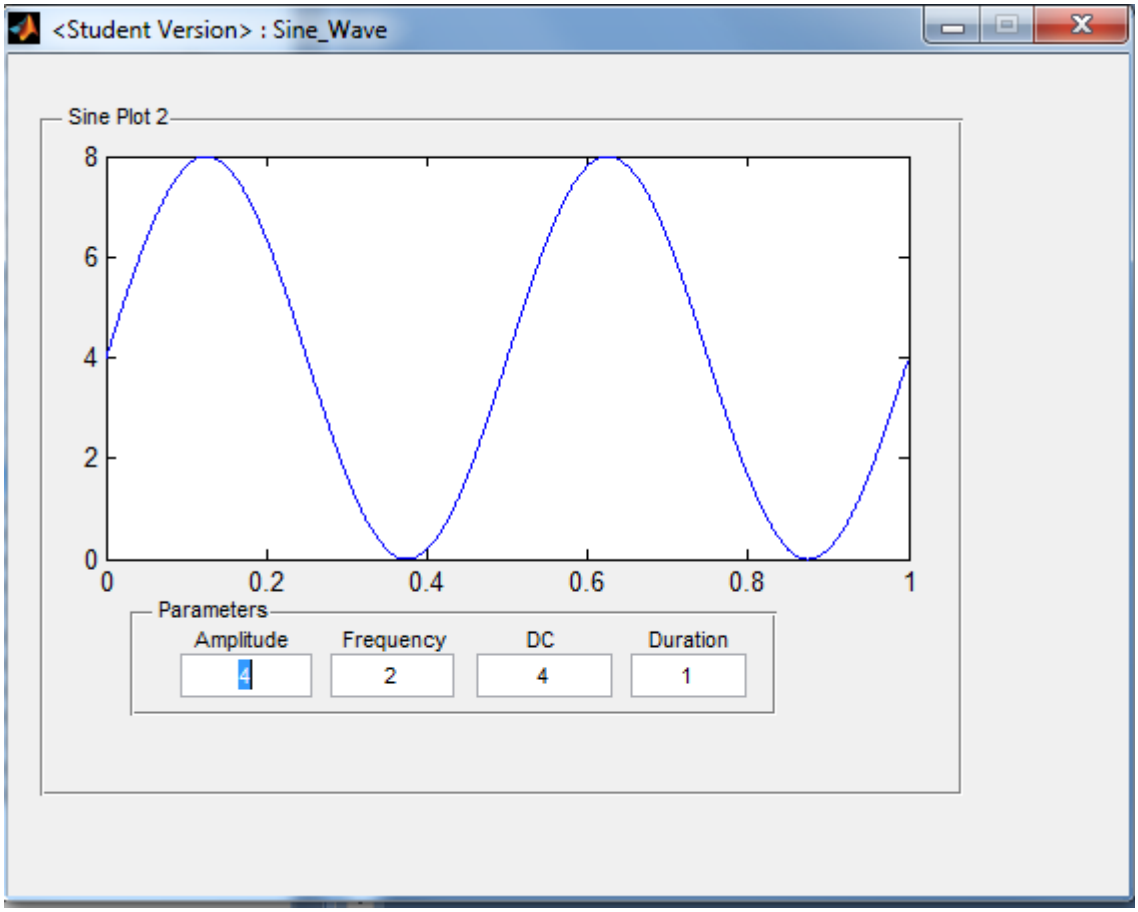


Figure 13: Sine Wave Example

As can be seen in figure 13 the plot is created and can be added to the EPSSE GUI by selecting the Update Plot push button on the EPSSE GUI. The sample rate for all signals is hard coded in the software to be 10Hz. Once the signal is plotted the data array is sent to the EPSSE GUI by using the setappdata function in MATLAB.

5.3 Slew GUI

The same idea as the Sine Wave GUI is implemented in the Slew GUI. As the name suggest this is a plot of a slew rate, that can be set by the user simply by the

$$y = mx + b$$

Equation 4: Slew Rate Equation

M is the slope, or slew rate of the signal in volts per second, and b is the DC offset of the signal. This can be seen from a formula of

$$y = 1x + 1$$

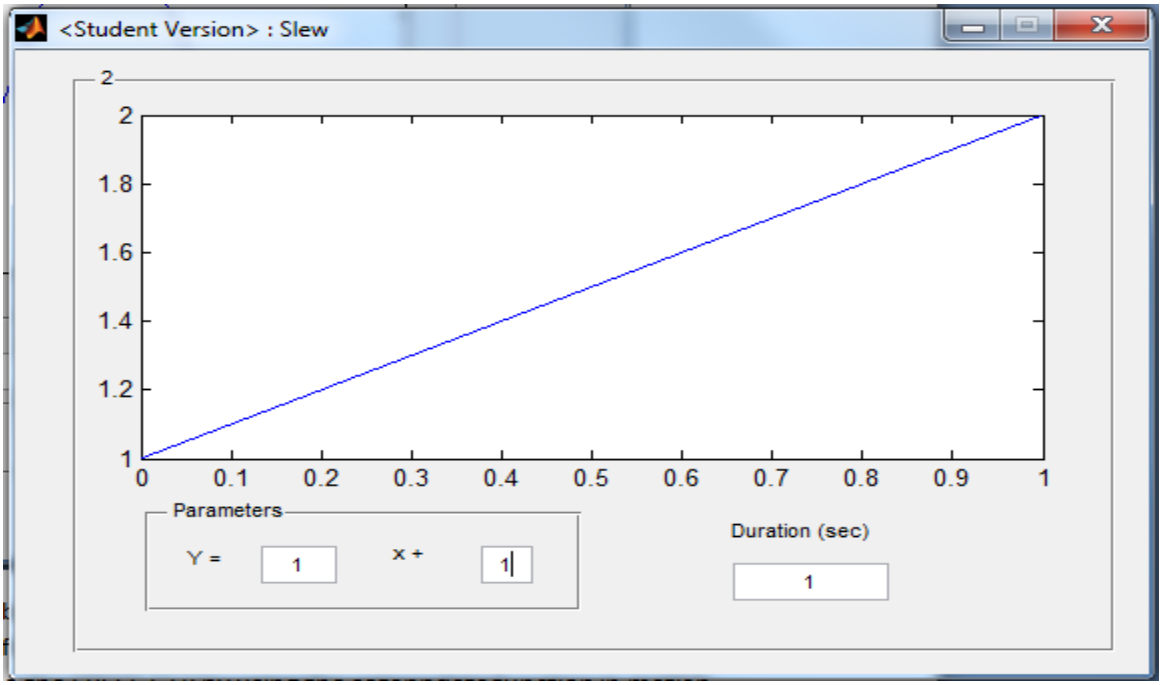


Figure 14: Slew Rate Example

As can be seen the signal starts at a 1, with a duration of 1 second and having a slope of 1.

5.4 Random GUI

As with the Sine Wave GUI and the Slew GUI, the Random GUI is used to create a Random signal.

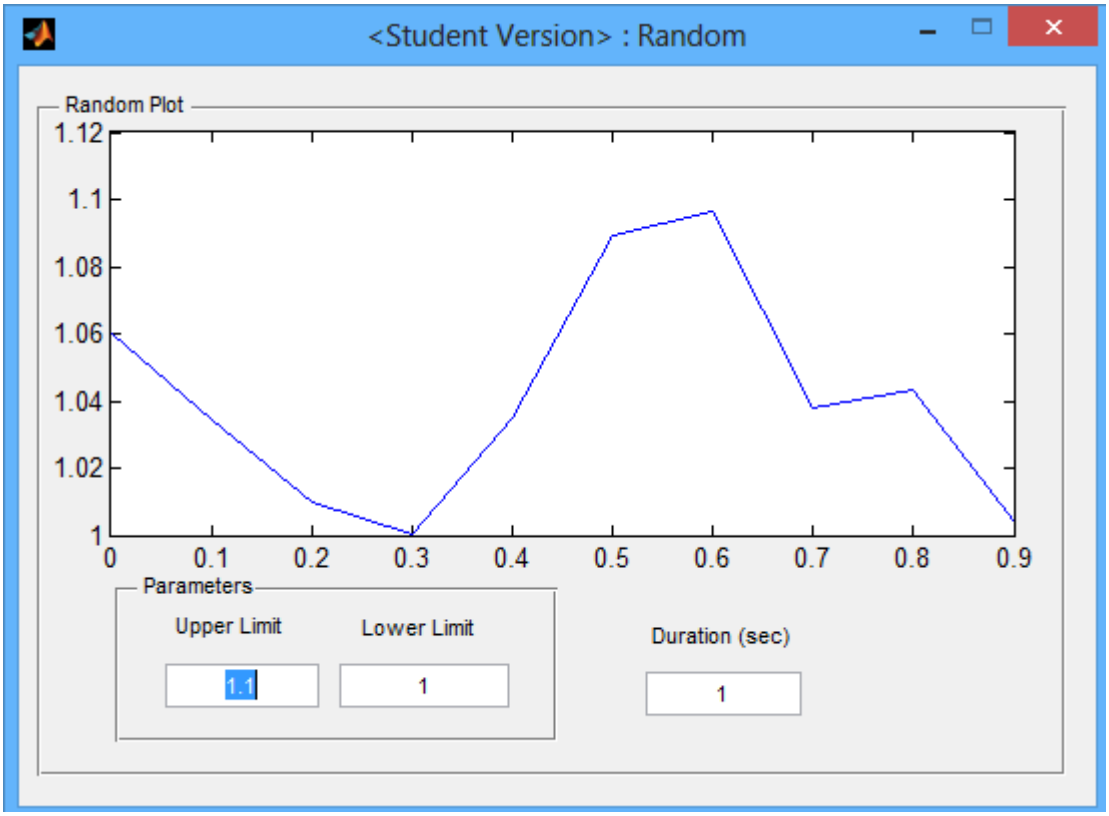


Figure 15: Random GUI

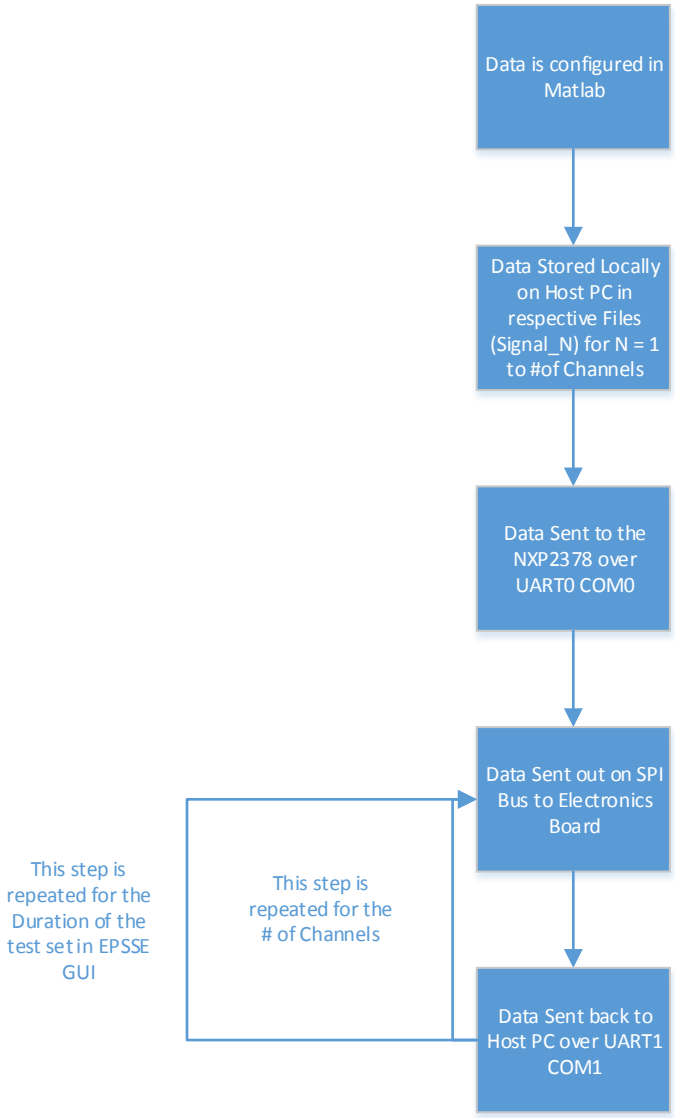
The upper limit is the upper limit on the randomness, for example this Upper limit is 1.1 and the lower limit is 1, thus the values will range from 1 to 1.1. The duration is 1 second. The random values are generated using a function which returns values that are Gaussian random distribution.

6 Data Loader Software

As stated in the Section 3 Overview, once the design is configured in the GUI, the software has to be downloaded to the microcontroller in order to run the test. The software that sets up all of the peripherals, and imports the files and values has the project name Data_Loader. The software's main function is to import the values which configure the test, hence the name Data_Loader. The software is written in the C programming language, with a function based approach.

The software is written so that a continuous flow of data is sent out to the Electronics, and sent back to the Host PC for real time data plotting. The flow diagram below indicates the flow of data during a simulation. As can be seen once the data is stored on the microcontroller in program memory (non-volatile), then the data is sent out to the electronics then sent back to the Host PC, this will repeat for the number of channels. The that loop will repeat for the duration set in the EPSSE GUI, or run forever if that is set in the EPSSE GUI. This is controlled using ifdef directives in the software.

Special consideration was taken so that the data would be sent out abiding by the timing which is set in the MATLAB GUI. Another word, the actual signals (voltage levels and timing) should match what was designed in the GUI.


Data is configured in Matlab
Data Stored Locally on Host PC in respective Files (Signal_N) for N = 1 to #of Channels
Data Sent to the NXP2378 over UART0 COM0
Data Sent out on SPI Bus to Electronics Board
Data Sent back to Host PC over UART1 COM1
This step is repeated for the # of Channels
This step is repeated for the Duration of the test set in EPSSE GUI

6.1 Startup Code

Each time the microcontroller is reset the bootloader configures the NXP2378 for the In System Programming (ISP), or In Application Programming (IAP). For this project ISP is used and flash memory is programmed over the UART0 port. This port is brought out on the board through the COM0 port.

Once the bootloader program is finished the startup code is ran. The startup code is a file that is included with the Keil IDE software. The startup code file is LPC.2300.s. This file can be used to setup the initial configuration of the NXP2378. The file is setup as to provide a configuration wizard, which

allows the user to easily configure the NXP2378. The configuration wizard is a GUI like interface. This file can be in C/C++ or assembly. Here is an example to illustrate:

```
;---------------------- Stack and Heap Definitions ---------------------------

;// <h> Stack Configuration (Stack Sizes in Bytes)
;//   <o0> Undefined Mode      <0x0-0xFFFFFFFF:8>
;//   <o1> Supervisor Mode     <0x0-0xFFFFFFFF:8>
;//   <o2> Abort Mode          <0x0-0xFFFFFFFF:8>
;//   <o3> Fast Interrupt Mode <0x0-0xFFFFFFFF:8>
;//   <o4> Interrupt Mode      <0x0-0xFFFFFFFF:8>
;//   <o5> User/System Mode    <0x0-0xFFFFFFFF:8>
;// </h>

UND_Stack_Size  EQU     0x00000000
SVC_Stack_Size  EQU     0x00000008
ABT_Stack_Size  EQU     0x00000000
FIQ_Stack_Size  EQU     0x00000000
IRQ_Stack_Size  EQU     0x00000100
USR_Stack_Size  EQU     0x00000400
```

Figure 16: Stack and Heap Configuration section in Startup file

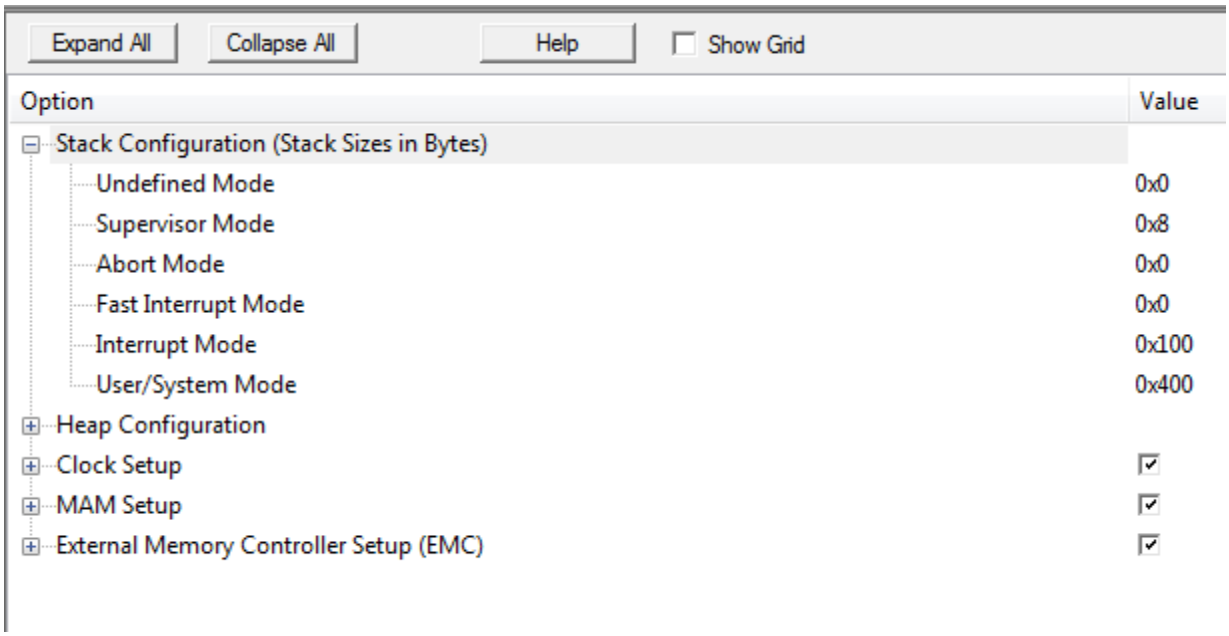


Figure 17: Configuration Wizard

Looking at figure 16 and figure 17, the highlighted box code corresponds to the configuration wizard in figure 17. Any change in the configuration will change the assembly code. This is very useful for initially configuring such peripherals on startup like Clock Setup for the PLL.

If the reset button on the EPSSE Simulator box is pressed the microcontroller will reset and the simulation will start over from the beginning. Observe the start LED to indicate the beginning of the simulation. The delay for start of simulation is hardcoded at a delay of 5 seconds. The startup code for the EPSSE Data Loader will be used to set the timing for the PCLK, CCLK, and power enable for peripherals. The PCLK and CCLK are used to clock the peripherals on the NXP2378.

6.2 SPI Configuration

The Serial Peripheral Interface (SPI) is a communication protocol which will be used in this project to interface with the Digital to Analog Converter (DAC). The SPI will send data that was computed in the EPSSE GUI.

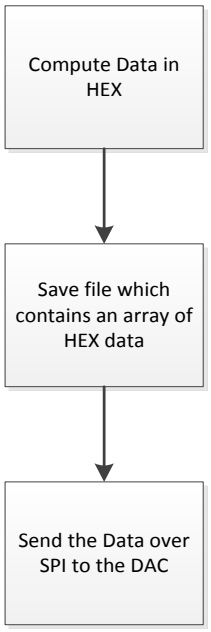


Figure 18: Flow of Data

As can be seen in figure 18, the SPI is responsible for transferring data to a device that can send out a voltage. According to the AD7303 DAC data sheet, data is clocked in to a shift register which is 16 bits wide. The first 8 bits are control bits, while the last 8 bits are the data. The SPI is configured first by setting the SPI0 control register and setting the Clock counter register. Of course the proper configuration of the pins using PINSELx registers should be set to configure the multiplexed pins on the NXP2378. The SPI is configured for 8 bits with no interrupts and set as the master. The device will always act as the master for this project, due to the fact that the AD7303 does not have the capability to write data back to the NXP2378. The clock counter is set to 6MHz. The PCLK for the SPI is the set at 12MHz. This is a clock rate of PCLK/8, which is under the required max clock rate of the AD7303, which is 30MHz. It also fits the stipulation of a value of greater than 8 for a master.

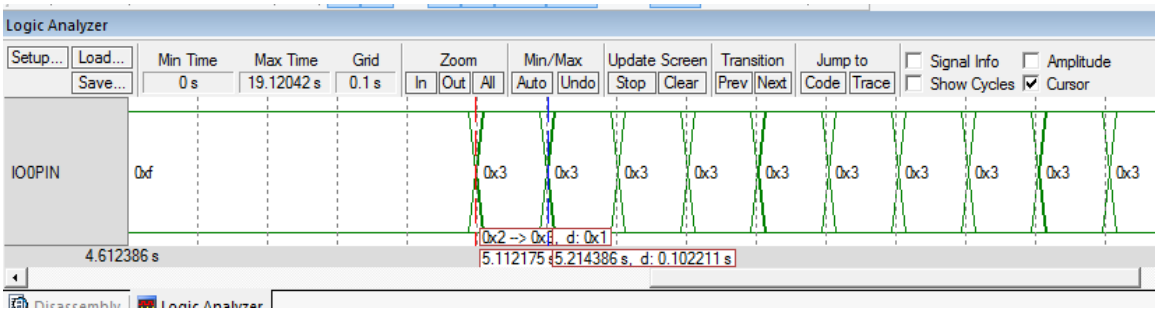


Figure 19: SPI Timing

Firgure 19, shows that for a write to the 4 DACs twice, each time a write occurs there is 16 bits of data written to each. First the control bits, and then the Data bits. As can be seen the time is 10Hz, or 0.1 seconds. The MATLAB GUI calls for 10 samples per second. This meets the design goal (3).

The SPI protocol is set up in the SSP0 peripheral on the NXP 2378. This peripheral can be set up as a SPI, 4 wire SSI, or microwire. For this config file getters and setters are used, and the SSP0 or SSP1 defines are used to set this up.

Figure 18 shows the c file which contains the functions for setting and getting the SSP peripheral.

```
39 void setSSPControl(int m_SSPCR0,int m_SSPCR1){
40
41   SSP0CR0 = m_SSPCR0;
42   SSP0CR1 = m_SSPCR1;
43
44 }
45
46 void sendSSPData(int m_Data){
47
48   SSP0DR = m_Data;
49 }
50
51 char getSSPStatus(void){
52
53   return SSP0SR;
54 }
55
56 void setSSPClock(char m_Clock){
57   SSP0CPSR = m_Clock;
58 }
59
60 void SPIConfig(){
61
62 #if defined (SSP0)
63   PINSEL3 |= 0x0003CF00;     //set SSP0 PINS
64 #elif defined (SSP1)
65   PINSEL3 = 0x0;
66 #endif
67
68   setSSPControl(0x0407,0x02);
69   setSSPClock(2);
70 }
```

Figure 20: SPI_config.c

The send8bits function is used to send 8 bits of data, two times consecutively. First the MSB to bit 8 is sent as the control bits. The SSP status register is polled to observe when the send data register is empty. Polling was decided above using interrupts, because in this situation an interrupt would take longer to service, then to just poll the bit in the status register. As can be seen in the code (figure 22), there is no process of clearing the status bit, this bit is self clearing.

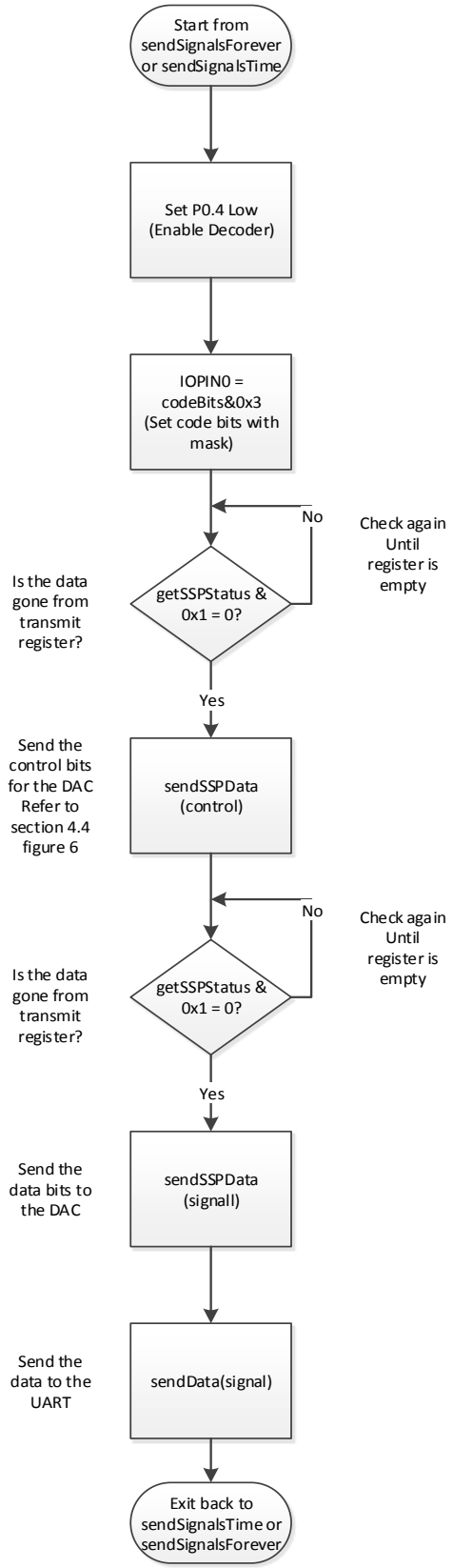

Start from sendSignalsForever or sendSignalsTime
Set P0.4 Low (Enable Decoder)
IOPIN0 = codeBits&0x3 (Set code bits with mask)
No
Check again Until register is empty
Is the data gone from transmit register?
getSSPStatus & 0x1 = 0?
Yes
Send the control bits for the DAC Refer to section 4.4 figure 6
sendSSPData (control)
No
Check again Until register is empty
Is the data gone from transmit register?
getSSPStatus & 0x1 = 0?
Yes
Send the data bits to the DAC
sendSSPData (signall)
Send the data to the UART
sendData(signal)
Exit back to sendSignalsTime or sendSignalsForever

Figure 21: send8Bits Flow Chart

```
70  //send8Bits
71  //control bits and data bits for AD7303
72  //code bits for the decoder
73  void send8Bits(unsigned char control,unsigned char signal,char code_bits)
74  {
75    IOCLR0 |= 0x8;
76    IOPIN0 = (code_bits  & 0x3);                  /*assert sync                */
77
78    while((getSSPStatus() & 0x01) == 0){          /*wait for the flag          */
79    }
80    sendSSPData(control);                         /*write control data         */
81
82    while((getSSPStatus() & 0x01) == 0){          /*wait for SPIF              */
83    }
84    sendSSPData(signal);                          /*write the signal           */
85
86    sendData(signal);
87  }
88
```

Figure 22: Send 8 bits function

6.3 UART Configuration

To plot real time data, the UART1 is used to interface with the host PC. The data sent out will be serial and sent out through the COM1 port. The UART is configured to set 8 bits of data at a baud rate of 11584. The signal that is sent out of the SPI is the same that is sent to the UART Transmit holding register. This will be the data captured by the host PC.

```
17  void UARTConfig(){
18
19    PINSEL0 = 0x1<<30;
20    PINSEL1 = 0x1;
21    U1LCR = 0x80;
22    U1DLL = 0x4;
23    U1DLM = 0;
24    U1LCR = 0x8B;
25    U1FCR = 3;
26    U1FDR = 0x85;
27    U1TER |= 0x80;
28    U1LCR = 0x0B;
29
30  }
31
32  char getUARTStatus(){
33    return U1LSR;
34  }
35
36  void sendData(unsigned char signal){
37
38    while(!(getUARTStatus() & m_THRE)){
39      ;
40    }
41    U1TER = 0x00;
42    U1THR = signal;
43    U1TER |= 0x80;
44  }
45
46
```

Figure 23: UART configuration and functions file

The file simply sets the proper pins on the microcontroller, then sets the baud rate according to the baud rate calculation given in section 4.4.2.2, and has a function that will poll the Line Status Register bits for transmission and then set the value that is passed in the function. The Transmit bit is set low before entering the data in the Transmit holding register, and this will how the data from being transferred to the Transmit shift register.

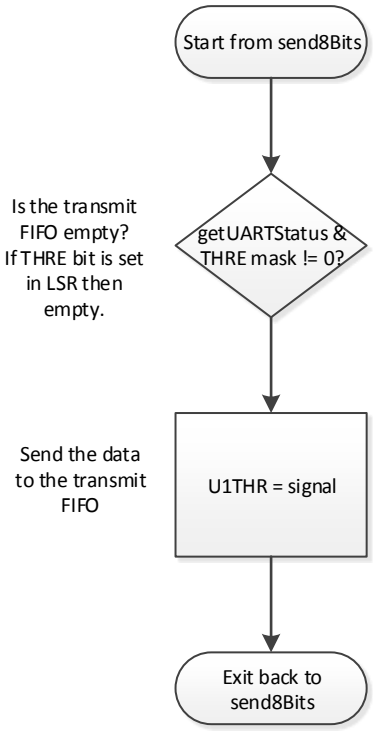

Start from send8Bits
Is the transmit FIFO empty? If THRE bit is set in LSR then empty.
getUARTStatus & THRE mask != 0?
Send the data to the transmit FIFO
U1THR = signal
Exit back to send8Bits

Figure 24: sendData Function Flow Chart

6.4 Delay Function

The delay function is used to set the output rate of the signal. To set up a delay, the Timer on the NXP2378 is used. This delay function takes an integer variable and creates a delay, which is the value of that integer. The delay function simply configures the Timer 0 registers and runs a while loop until the Timer 0 interrupt flag is not set, then clears the flag and resets the Timer.

```
/*****************************************************************************/
/* Function:  delay                                                          */
/* variables: time - sets the delay time in uSec                             */
/*****************************************************************************/

void delay(int time)
{
  T0TCR= 0x2;                   /*reset the TC                              */
  T0PR = 0x0B;                  /*prescale register                         */
  T0PC = 0x00;                  /*Prescale counter                          */
  T0MR0=time;                   /*match0 register                           */
  T0MCR=0x03;                   /*control register int/reset/stop           */
  T0TCR=0x1;                    /*enable the TC                             */

  while(T0IR==0){
  }

  T0IR  = 0x1;
  T0TCR = 0x03;
}
```

Figure 25: Delay Function C Program

6.5 Main

The main function is used to configure all of the peripherals, and use the functions to send data to the DAC. The SPI, and UART are configured and then a function to send the data out is ran. This function will send the data to the DAC for the duration of the simulation. The simulation can be ran for the duration of the signal designed in the EPSSE GUI, or can run continuously until the reset button is pressed, or the power is disconnected. Line 59 through 63 implement an ifdef else endif, which will run one or the other dependent on the selection during the design. There is a delay for the LED to signal the beginning of the Test. This LED will be present and labeled on the outside of the EPSSE Simulator box.

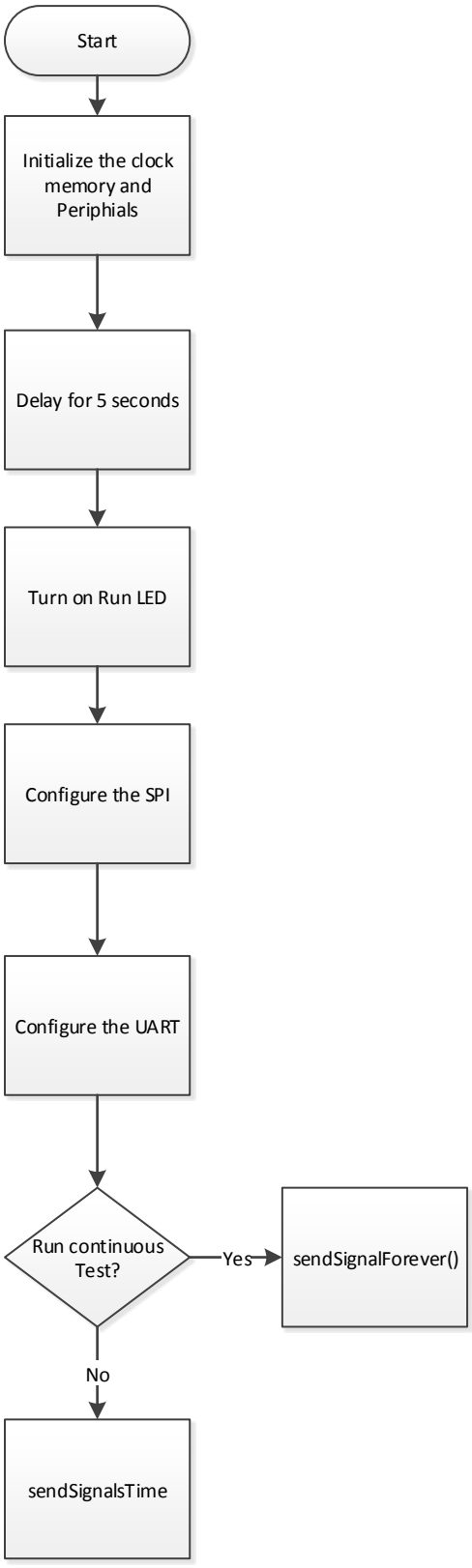


Figure 26: Main Loop Flow Chart

```
39  main()
40  {
41  startDelay(duration);
42  IODIR0 = 0x1FF;
43  IOCLR0 = 0x8 && 0xF;
44  SSPConfig();
45  UARTConfig();
46  #ifdef forever
47  sendSignalsForever();
48  #else
49  sendSignalsTime(duration);
50  #endif
51  }
52
```

Figure 27: Main Function

The main function calls functions which are included in the file. Once of those is the sendSignalsForever, and the other is sendSignalsTime. The sendSignalsTime function is ran in the program if the user has not checked the Continuous Radio Button in the EPSSE MATLAB GUI. The duration is the variable that is passed to the function, and is set as a default of 1. Length is set in the EPSSE MATLAB GUI as the max of all of the signal vectors, thus the inner loop of the program will cycle until the last value of the longest signal configured in the EPSSE MATLAB GUI.

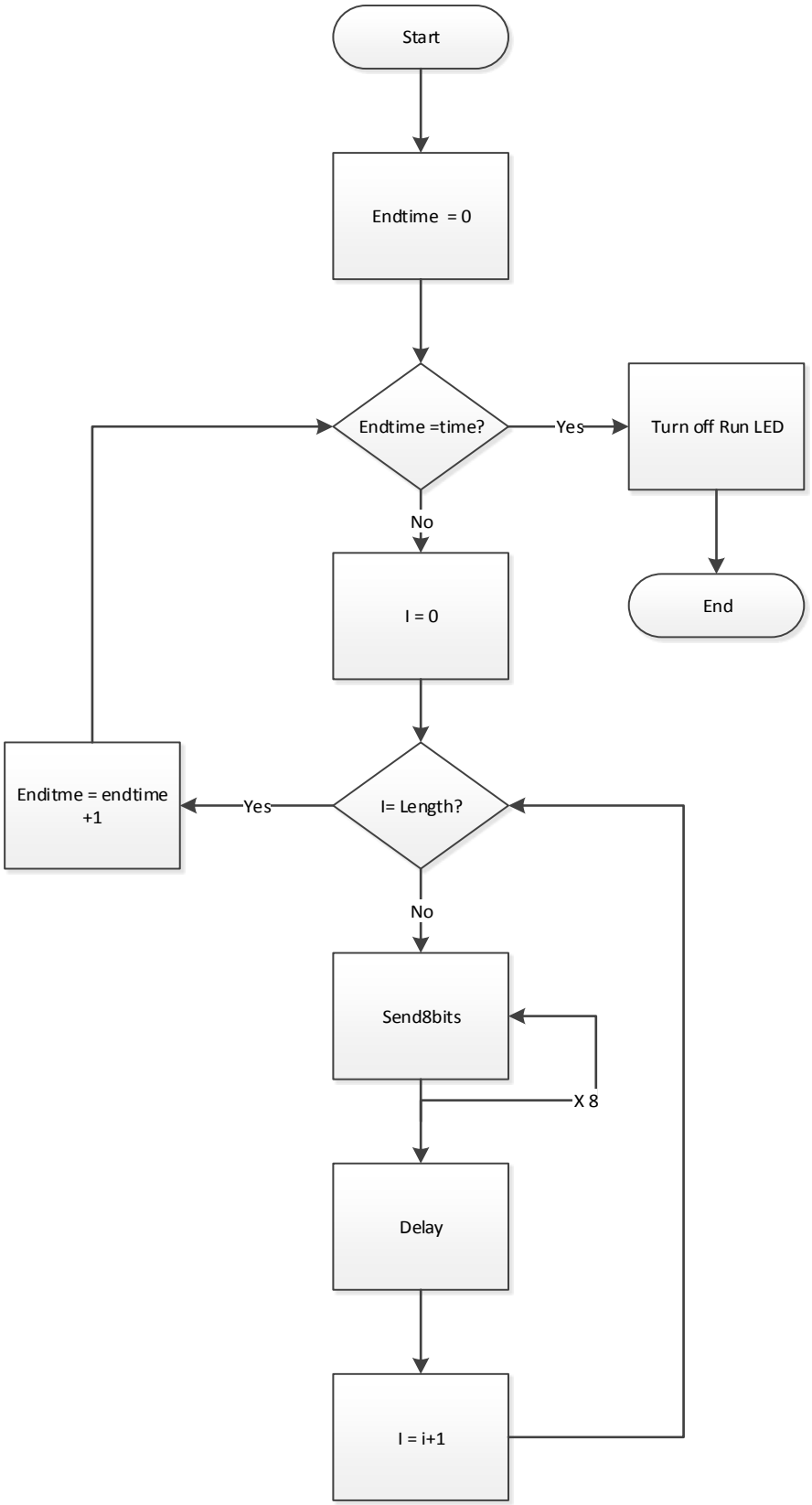

Start
Endtime = 0
Endtime =time?
Yes
Turn off Run LED
End
No
I = 0
Enditme = endtime +1
Yes
I= Length?
No
Send8bits
X 8
Delay
I = i+1

Figure 28: sendSignalsTime Flow Chart

```
131  //sendSignalTime
132  //time for the signal to run
133  void sendSignalsTime(int time)
134  {
135        int i;
136        unsigned char signal;
137        int end_time = 0;
138
139        while(end_time < time)
140        {
141          for(i=0;i<length;i++)
142          {
143
144            signal = Signal_1[i];
145            send8Bits(3,signal,0);
146
147            signal = Signal_2[i];
148            send8Bits(3,signal,1);
149
150            signal = Signal_3[i];
151            send8Bits(3,signal,2);
152
153            signal = Signal_4[i];
154            send8Bits(3,signal,3);
155
156            signal = Signal_5[i];
157            send8Bits(7,signal,0);
158
159            signal = Signal_6[i];
160            send8Bits(7,signal,1);
161
162            signal = Signal_7[i];
163            send8Bits(7,signal,2);
164
165            signal = Signal_8[i];
166            send8Bits(7,signal,3);
167            delay(100000);
168          }//end for
169        end_time++;
170      }//end while
```

Figure 29: sendSignalsTime function

The sendSignalsForever function will run an endless loop.

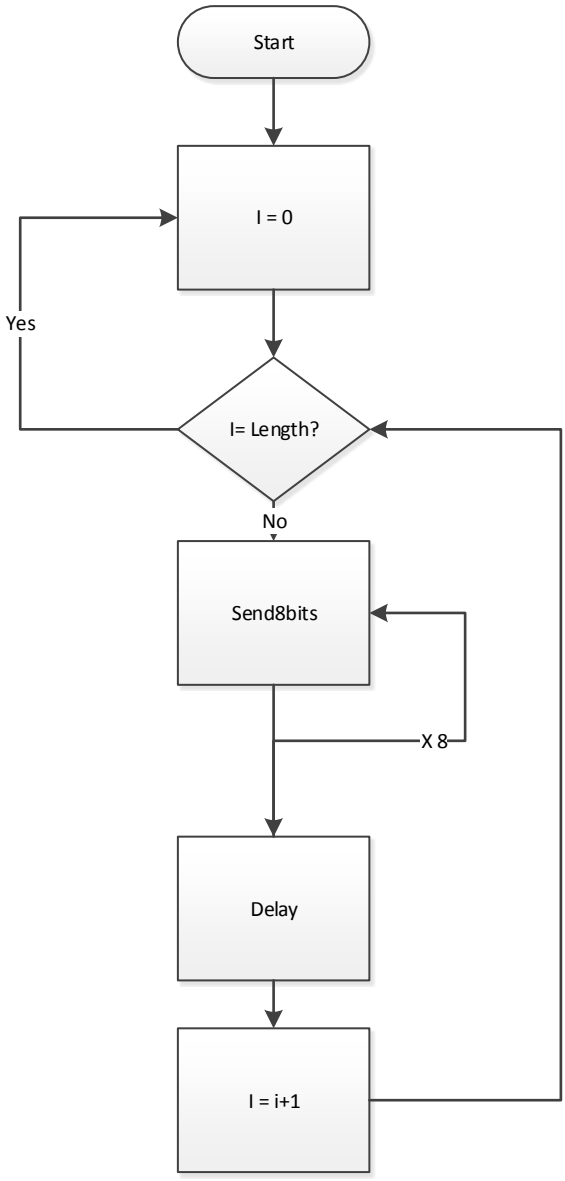


Figure 30: sendSignalsForever Flow Chart

```
89  //sendSignalForever
90  //Variables: none
91  void sendSignalsForever(void)
92  {
93    int i;
94    unsigned char signal;
95
96
97    while(1)
98      {
99        for(i=0;i<length;i++)
.00       {
.01         signal = Signal_1[i];
.02         send8Bits(0x03,signal,0);
.03
.04         signal = Signal_2[i];
.05         send8Bits(0x3,signal,1);
.06
.07         signal = Signal_3[i];
.08         send8Bits(0x3,signal,2);
.09
.10         signal = Signal_4[i];
.11         send8Bits(0x3,signal,3);
.12
.13         signal = Signal_5[i];
.14         send8Bits(0x7,signal,0);
.15
.16         signal = Signal_6[i];
.17         send8Bits(0x7,signal,1);
.18
.19         signal = Signal_7[i];
.20         send8Bits(0x7,signal,2);
.21
.22         signal = Signal_8[i];
.23         send8Bits(7,signal,3);
.24
.25         delay(100000);
.26       }//end for
.27     }//end while
.28   }//end function
.29
.30
```

Figure 31: sendSignalsForever Function

7 MATLAB Real time Plot

The MATLAB real time plot is a real time plot of the simulation data which is sent to the CSUNSat1 main processor. This is done over a serial to USB connection from the EPSSE simulator box, to the Host PC. The NXP2378 utilizes the UART1 communications terminal to send data to the Host PC. The script is a based on the real time data plot from a serial port, by Moidu Thavot.

The script first sets up eight plots which will fill the screen. These plots are then updated every 100 milliseconds. Which is the rate of output of the DAC IC's. These values are then converted back and plotted.

```
2 -    delete(instrfindall);
3 -    board = serial('COM5', 'baudrate',115834,'parity','odd','InputBuffer',8);
4 -    fopen(board);
5      %set the time interval to grab data
6 -    timeStep = 0.1;
7      %set the number of times to grab data.
8      %
9
10 -   loop = 50;
11 -   voltage = 0;
12 -   voltage2 = 0;
13 -   time = clock;
14 -   time2 = clock;
15 -   scrsz = get(0,'ScreenSize');
16
17     %locations
18 -   topleft = [1 scrsz(4) - (scrsz(4)/4) scrsz(3)/2 scrsz(4)/4];
19 -   secfrtopleft = [1 scrsz(4) - 2*(scrsz(4)/4) scrsz(3)/2 scrsz(4)/4];
20 -   thrfrtopleft = [1 scrsz(4) - 3*(scrsz(4)/4) scrsz(3)/2 scrsz(4)/4];
21 -   botleft = [1 scrsz(4) - 4*(scrsz(4)/4) scrsz(3)/2 scrsz(4)/4];
22 -   toprigth = scrsz(4) - (scrsz(4)/4);
23 -   secfrtopright = scrsz(4) - 2*(scrsz(4)/4);
24 -   thrfrtopright = scrsz(4) - 3*(scrsz(4)/4);
25 -   botright = scrsz(4) - 4*(scrsz(4)/4);
26 -   wholeScrn = [1 1 1 1];
```

First all instruments are found and deleted, as to not have any conflicts. Then the serial port is opened all of the properties are set. The COM port should be set according to the proper location. The screen size is used to set the location of all of the plots, as to make the code portable. Each figure is configured to be aesthetically pleasing to the user. All labels and titles are also set. This is somewhat of an initialization.

```
28      %set up the figures
29 -    channel_4 = figure('NumberTitle','off','Name','Channel 4',...
30          'Color',[0 0 0],'Visible','off','Position',botleft,'MenuBar','none');
31 -    axesHandle4 = axes('Parent',channel_4,...
32          'YGrid','on','YColor',[0.9275 0.9275 0.9275],...
33          'XGrid','on','XColor',[1 1 1],...
34          'Color',[0 0 0]);
35 -    hold on;
36
37 -    plotHandle4 = plot(axesHandle4,time,voltage,'Marker','.','LineWidth',1,'Color',[0 1 0]);
38 -    xlim(axesHandle4,[min(time) max(time+0.001)]);
39 -    labelColor = [1 1 0];
40 -    xlabel('Parent',axesHandle4,'Time','Color',labelColor);
41 -    ylabel('Parent',axesHandle4,'Signal','Color',labelColor);
42 -    title('Parent',axesHandle4,'Channel 3','Color',labelColor);
43
```

```
while ~isequal(count, loop);

    voltage1(count) = ((fread(board,1,'uint8')')/256)*5.25
    voltage2(count) = ((fread(board,1,'uint8')')/256)*5.25
    voltage3(count) = ((fread(board,1,'uint8')')/256)*5.25
    voltage4(count) = ((fread(board,1,'uint8')')/256)*5.25
    voltage5(count) = ((fread(board,1,'uint8')')/256)*5.25
    voltage6(count) = ((fread(board,1,'uint8')')/256)*5.25
    voltage7(count) = ((fread(board,1,'uint8')')/256)*5.25
    voltage8(count) = ((fread(board,1,'uint8')')/256)*5.25
    time(count) = count;

    set(plotHandle1,'YData',voltage1,'XData',time);
    set(channel_1,'Visible','on');
    datetick('x','SS:FFF');

    set(plotHandle2,'YData',voltage2,'XData',time);
    set(channel_2,'Visible','on');
    datetick('x','SS:FFF');
```

The while loop will update the values for all the plots and then plot each in the appropriate figure. The loop variable is set from passing the duration computed in the EPSSE MATLAB GUI. This variable will be the duration of the longest signal.

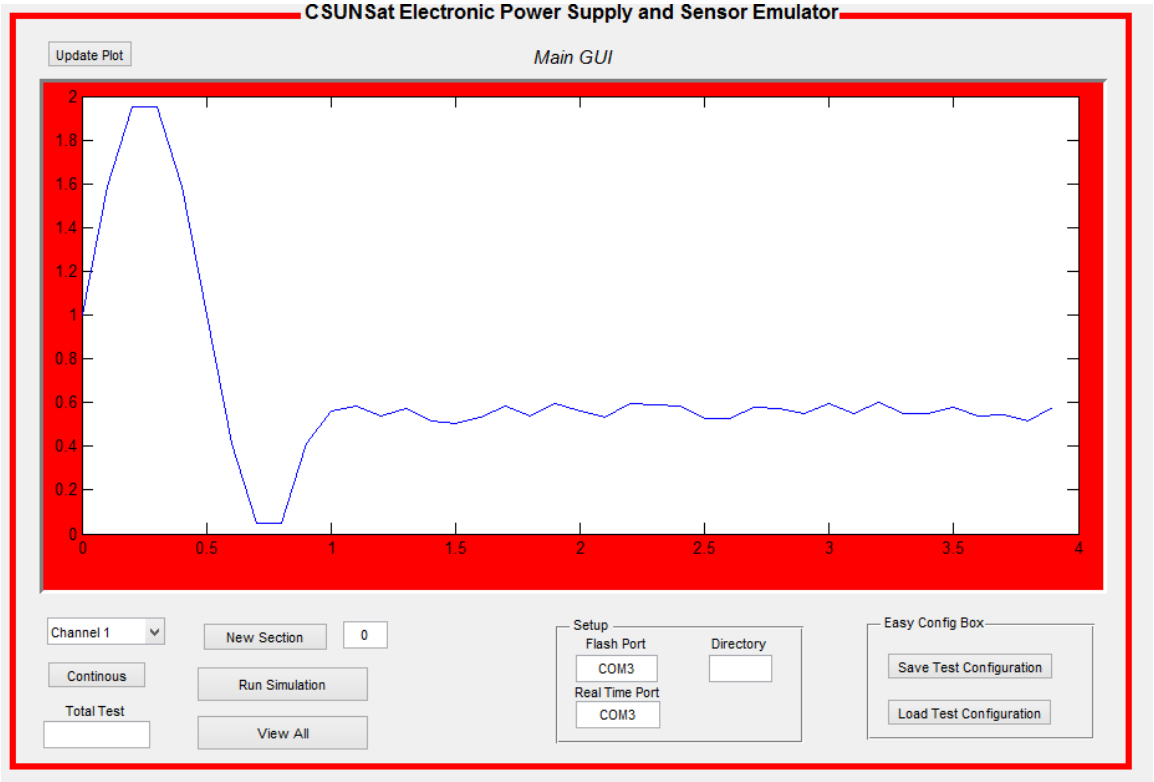


Figure 32: Signal 1 Design plot in Main GUI

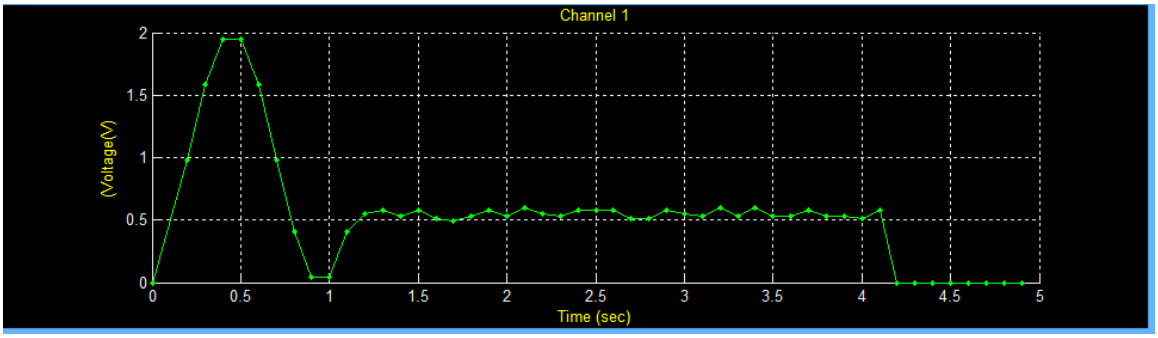


Figure 33: Real Time Plot for Signal 1

8 Schematic

8.1 Simulator Box

The simulator EPSSE simulator Box is a metal box that houses the electronics and the MCB2300 development board. It was decided that the MCB2300 development board, (as opposed to designing a printed wiring board which contains the NXP2378, designed specifically for the purpose of this project),would be a cheaper solution. The MCB2300, provides more functionality than is needed, but as stated before the design is cheaper and still serves the purpose.

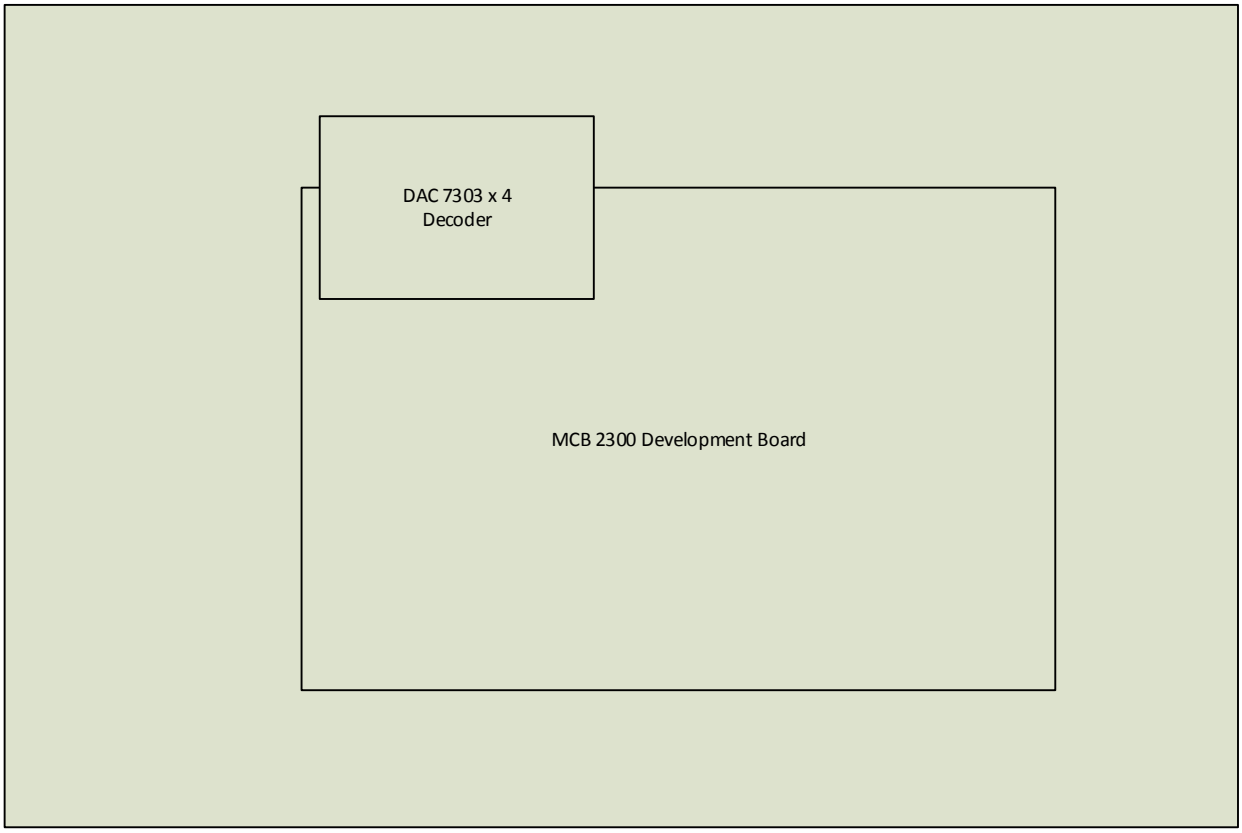


Figure 34: Inside of Simulator Box

Figure 30 shows the orientation and location of the development board and Electronics inside the EPSSE Simulator Box. None of the electrical connections are shown, and will be shown in the next section. Both are mounted to the bottom of the box, and the Electronics are mounted above the MCB2300 Development board by approximately and inch and a half.

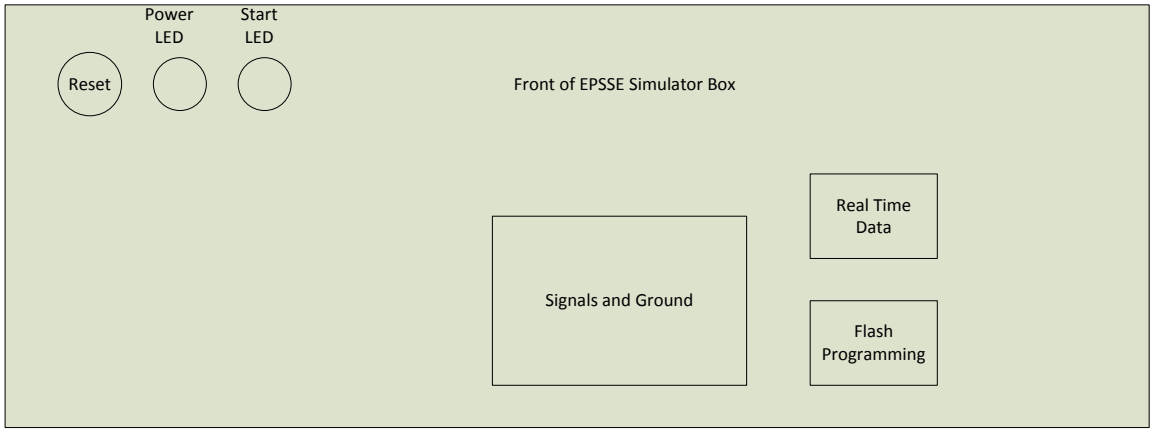


Figure 35: EPSSE Simulator Box Front Panel

The power connection is an open port and will not be sealed. This is decided so that it can also serve as some ventilation for the components inside the box. The temperature of the components is not anticipated to reach high temperatures, so this is just a precaution. The reset button will reset the NXP2378 and thus restart the test. The start LED will indicate that the test has started, the power LED indicates that power is supplied to the box. The COM ports on the front of the box provide the flash programming and real time data.

8.2 Electrical Connections

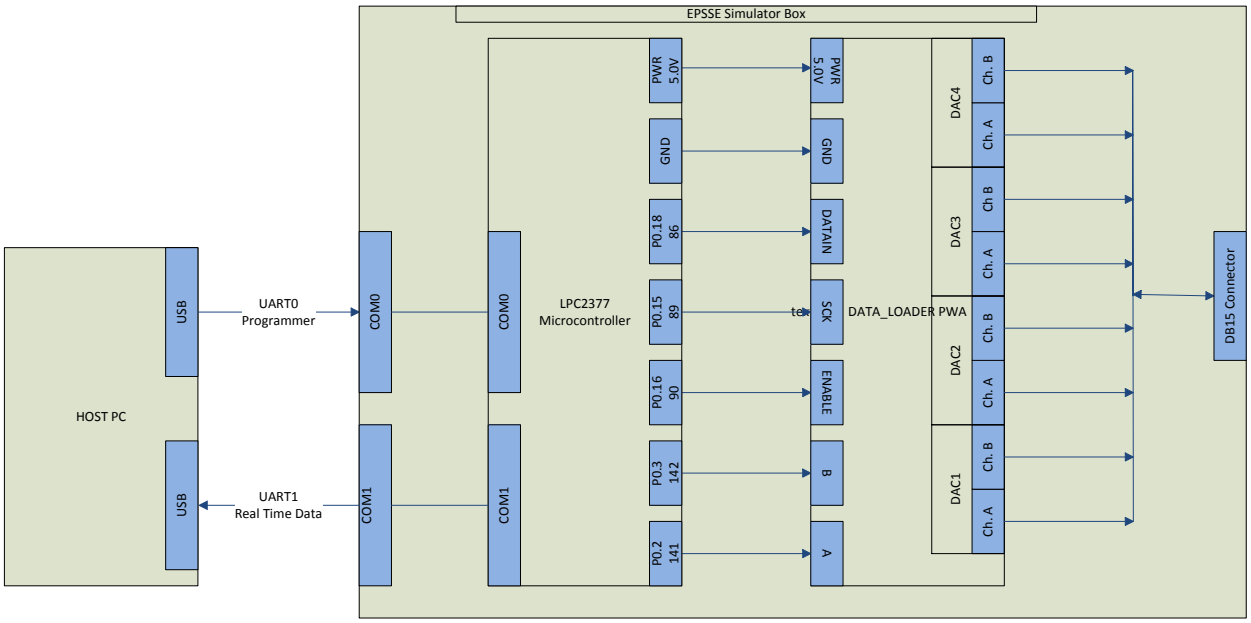


Figure 36: Inter Connect Diagram

The electrical connections inside the box are indicated in figure 36, and tables 6 and 7. The MCB2300 development board will provide power and ground for the Electronics. The Host PC will communicate to the EPSSE Simulator box over the two COM ports. A DB15 Connector provides the signals out of the box.

microcontroller			Host PC
PIN	PORT	FUNCTION	PORT
N/A	COM0	LOAD Signal Data	USB
N/A	COM1	Real Time Data	USB

Table 7: Host PC to Microcontroller

microcontroller		PWA	
PIN	PORT	PIN	FUNCTION
66	P0.0	A	DECODER BIT0
67	P0.1	B	DECODER BIT1
54	P1.23	DATAIN	SPI DATA IN
49	P1.20	SCK	CLOCK
116	P0.4	ENABLE	DECODER ENABLE
PWR	PWR	PWR	POWER
GND	GND	GND	GND

Table 8: Microcontroller to Electronics PWA

9 Conclusion

To conclude the design was for a system to test that CSUNSat1 main processor can meet the requirements step forth in the Requirements document [7]. The goals are to give the user a user friendly GUI to configure the test, send the data at the correct voltage levels at a rate which the main processor should be able to sample the data.

This was accomplished using MATLAB to design a user friendly GUI. Writing software which would send values to the electronics at a rate as to meet the sample rate the CSUNSat1 main processor will sample data. Implementing an electronics design to output the correct voltage to test the limits of the CSUNSat1 main processor. Designing the system memory to store enough values to run a test duration which would test the limits of the CSUNSat1 main processor.

The results show that the EPSSE can output voltages between 0V to 5.25V. The rate the values change is 10Hz. The total duration per channel used is stated in table 1. The GUI was designed for the user to save and load configurations, therefore cutting down on setup time. Designed to give the user the option to create a combination of signals to perform many different test. The EPSSE GUI gives the user the ability to monitor the data in real time to track any time at which an anomaly occurs, and the user can view all of the simulation plots at once. In conclusion the EPSSE GUI was designed with the user in mind.

References

1. UM10211 NXP2378 USER's MANUAL, REV. 4.1, September 5, 2012. Copyright NXP B.V 2012

2. AD7303 Data Analog Devices, Sheet One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A. Fax: 617/326-8703 © Analog Devices, Inc., 199

3. Processor I/O and Handshaking Rev. 2/25/2013, http://www.ece.uidaho.edu/ee/classes/ECE340/Lecture_Notes/L20/LCDhandshaking.pdf

4. MM74HC139 Data Sheet, Fairchild Semiconductors, Rev. February 1999,

5. MATLAB Creating Graphical User Interfaces, The MathWorks, Inc.3 Apple Hill Drive Natick, MA 01760-2098, © COPYRIGHT 2000–2013 by The MathWorks, Inc.

6. http://en.wikipedia.org/wiki/Test_engineer

7. Reference to requirements specification for CSUNSat1 Revision 1.1

8. MCB2300-v47 Schematic. 02/20/2008, provide by Keil Tools by ARM, ARM INC 4965 Preston Park Road, Suite 650 Plano, TX 75093

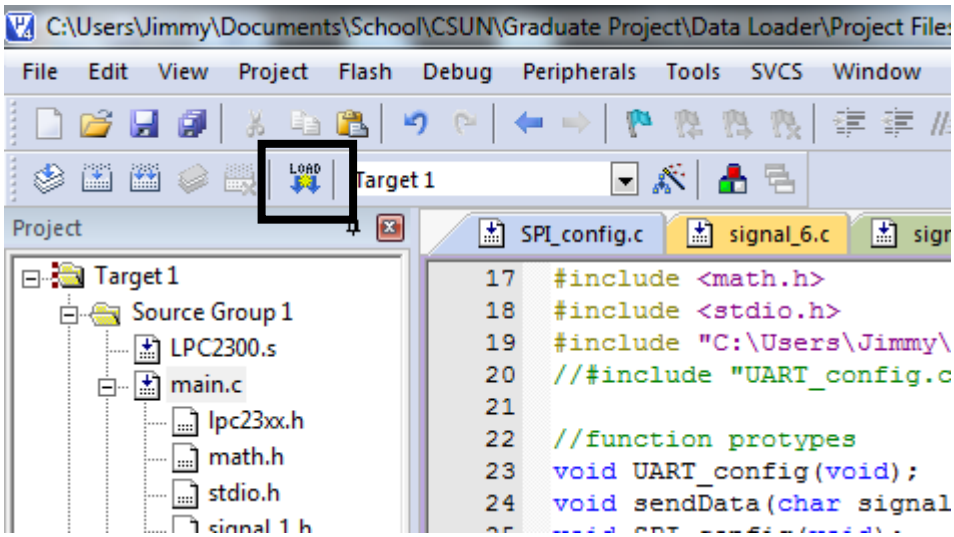
9. MAX563 Data Sheet, MAXIM Integrated Products, 120 Sab Gabriel Drive, Sunnyvale, CA 94086

Appendix

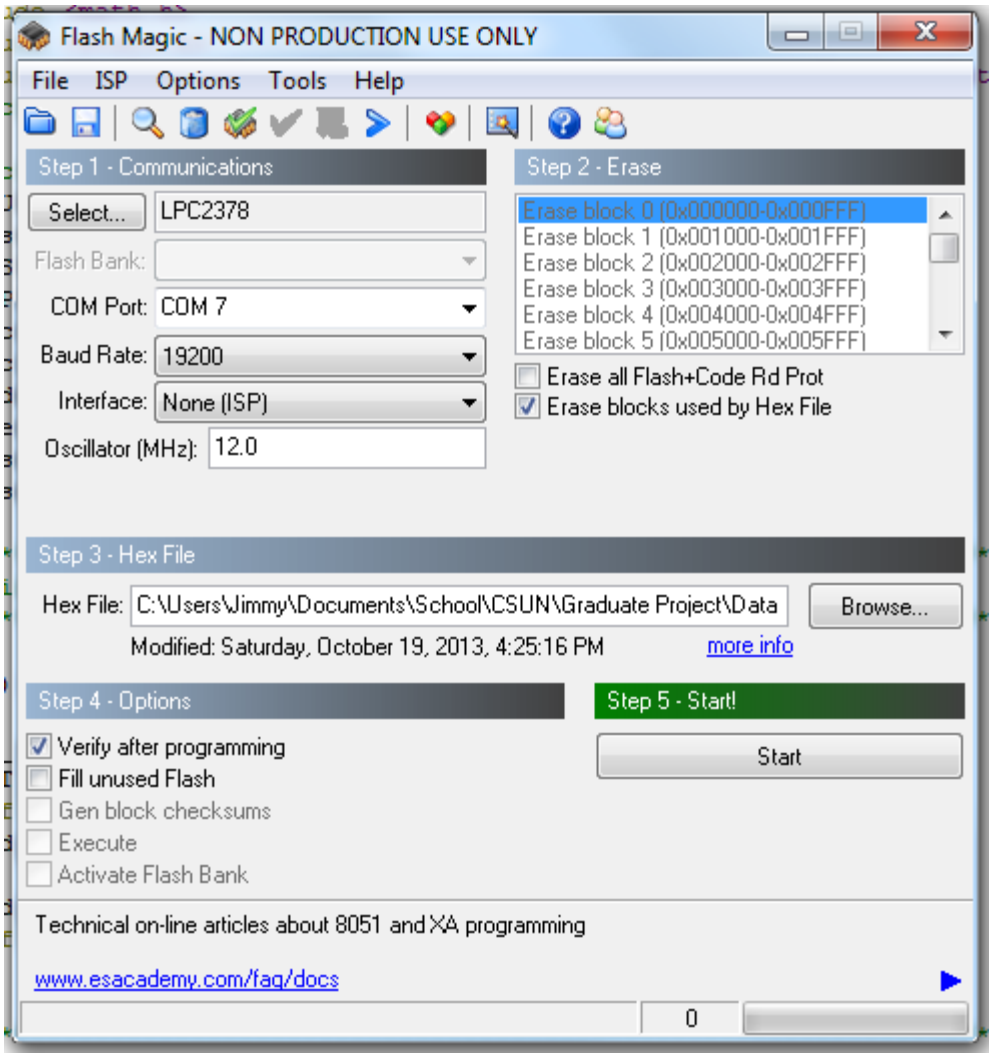
10.1 Downloading to Flash Memory

The process to download to flash memory without using the batch file and the EPSSE GUI is outlines below.

1. From the Keil IDE select the start flash magic icon.



2. The flash magic program will start



To configure correctly make sure that the correct COM port is selected and that Baud Rate is correct. The oscillator should be set to 12MHz, which is what the boot loader selects for the default timing device.

3. Select the correct Hex file. The Hex file should be created once a build of the program is finished.

4. Select the "Start Button" and the code should start downloading to the microcontroller.

10.2 Keil IDE Emulator

The Keil IDE is used for this project for software development and debugging. The Keil IDE incorporates an emulator in the IDE. This is very useful in debugging code, as will be demonstrated in the following example. In this example the emulator is used to validate the SPI configuration by stepping through the main code.

To start the build must be clean of errors, and the debug mode must be selected. Then from the tool bar select “peripherals”. A drop down menu gives you the option to select any of the peripherals, for this demonstration the SPI was selected. Now as in figure 16.

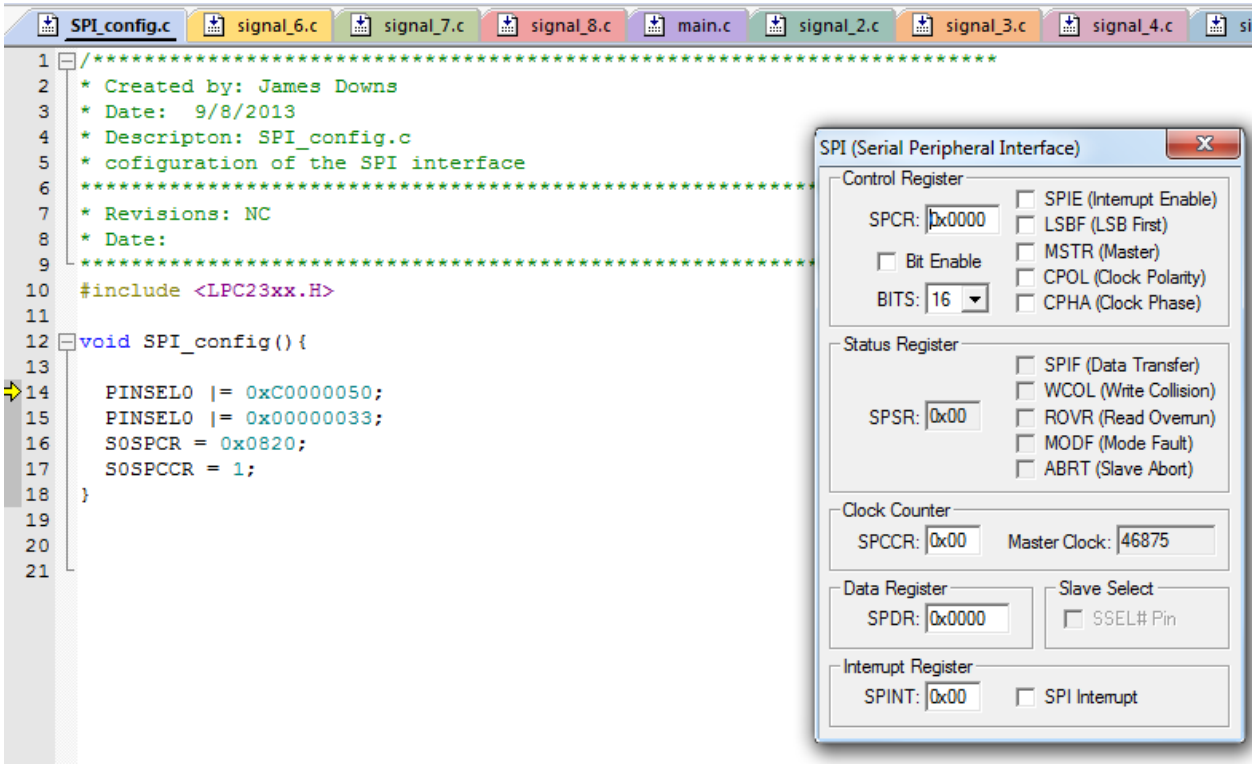


Figure 37: SPI Emulator

Once the emulator is up as you step through the code the SPI emulator will indicate the configuration of the SPI.

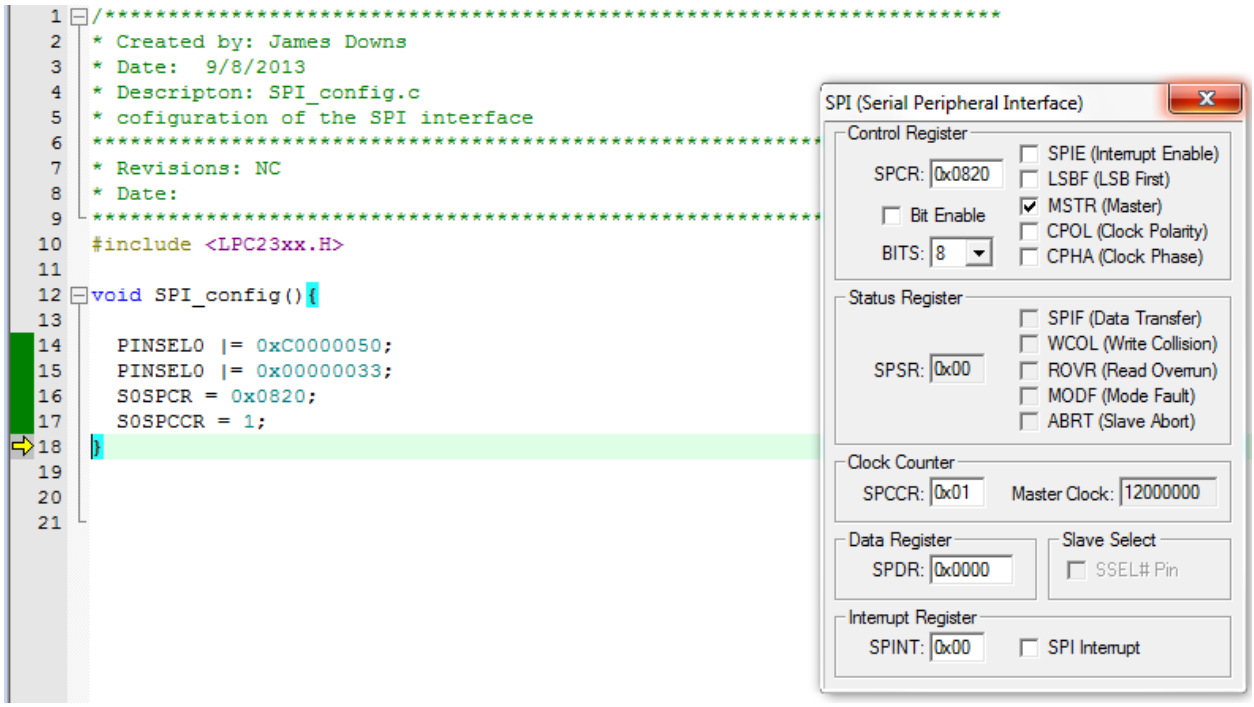


Figure 38: SPI Configuration Emulator Validation

As can be seen in figure 17, the SPI has been configured as the master, with a master clock of 12MHz, and an 8 bit write mode. For a complete understanding of Keil IDE document xxx.

10.3 EPSSE User's Manual

The EPSSE is designed to emulate the power supply and the sensors for the CSUNSat1 Cubesat. This user's manual will serve as a guide for

a. Providing the connection instructions

b.

10.3.1 Hardware Items

The following items are needed and should be used for the connection and use of the EPSSE

1. EPSSE Simulator Box

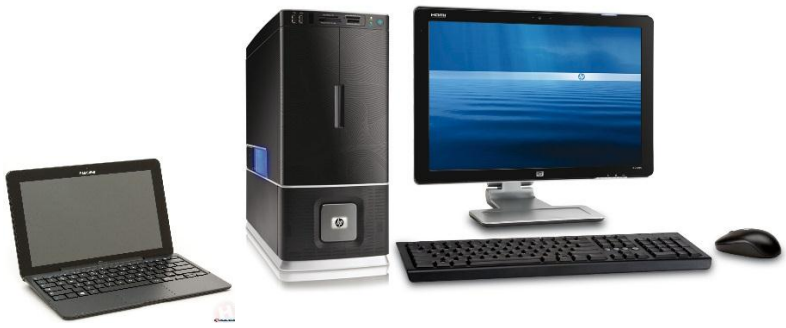
   TBD

Figure 1: EPSSE Simulator Box

2. 2 Serial to USB cables, 1 for flash programming, and 1 for UART real time data.

3. Wall power plug, or computer power cord with DC power input plug.

4. Personal Computer, Workstation or any type of Computer



5. Flash drive with software of software files located on the computer

10.3.2 Hardware Configuration

To set up a test or simulation follow these steps.

1. First of all the connections between the EPSSE simulator box and the Host computer must be made. As well as the connection to the CSUNSat1 processor.
2. First connect the USB to serial cable into the front of the EPSSE simulator box. The connection is a DB9 connector which is labeled Flash Program and USB to computer
3. Next connect the USB to serial cable into the front of the EPSSE simulator box, the connection is a DB9 connector labeled Real Time Data. Serial Side to box, and USB to computer.
4. Connect the power cord to the EPSSE simulator box.
5. Connect all cables to USB ports on the computer
6. If done correctly the Power LED on the box should be lit, and the COM port on the Computer should recognize the EPSSE simulator box.

10.3.3 COM PORT and Batch File Configuration

The createBatchFile function in the matlab code will create a batch file for the user. Due to the fact that the compiler and arm tools may be located in a different location on one computer

than another, the user must edit the function in order to user this to run the simulation. This is done by locating the compiler on the computer. This computer stores the compiler at C:\Keil

ARM\ARMCC\bin. This part of the function must be edited! If no then the batch file will not compile the c program and the test will not run. The drive will be found for the user, but again the batch file must be located.

```
% create a batch file
function createBatchFile()
drive = sprintf('%s',findDir());
cd(drive);
batchFile = fopen('Graduate Project\Data Loader\Project Files\Target_3.0.bat','wt');
%I:\Graduate Project\Data Loader\Project Files
fprintf(batchFile,'SET PATH=C:\\Keil\\ARM\\ARMCC\\bin\\;C:\\Windows\\system32;C:\\Windows;C:\\Windows\\Sy
fprintf(batchFile,'SET CPU_TYPE=LPC2378\n');
fprintf(batchFile,'SET CPU_VENDOR=NXP (founded by Philips)\n');
fprintf(batchFile,'SET UV2_TARGET=Target 1\n');
fprintf(batchFile,'SET CPU_CLOCK=0x00B71B00\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\main.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\spi_config.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\uart_config.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmAsm" --Via ".\\lpc2300._ia"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\signal_1.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\signal_2.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\signal_3.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\signal_4.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\signal_5.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\signal_6.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\signal_7.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmCC" --Via ".\\signal_8.__i"\n');
fprintf(batchFile,'"C:\\Keil\\ARM\\ARMCC\\bin\\ArmLink" --Via ".\\Data_Loader_Rev_A.lnp"\n');
fprintf(batchFile,'C:\\Keil\\ARM\\ARMCC\\bin\\fromelf.exe ".\\Data_Loader_Rev_A.axf" --i32combined --outp

fprintf(batchFile,'FM @"%sGraduate Project\\Data Loader\\Project Files\\flashcmds.txt"',drive);
%--------------------------------------------------------------------------
```

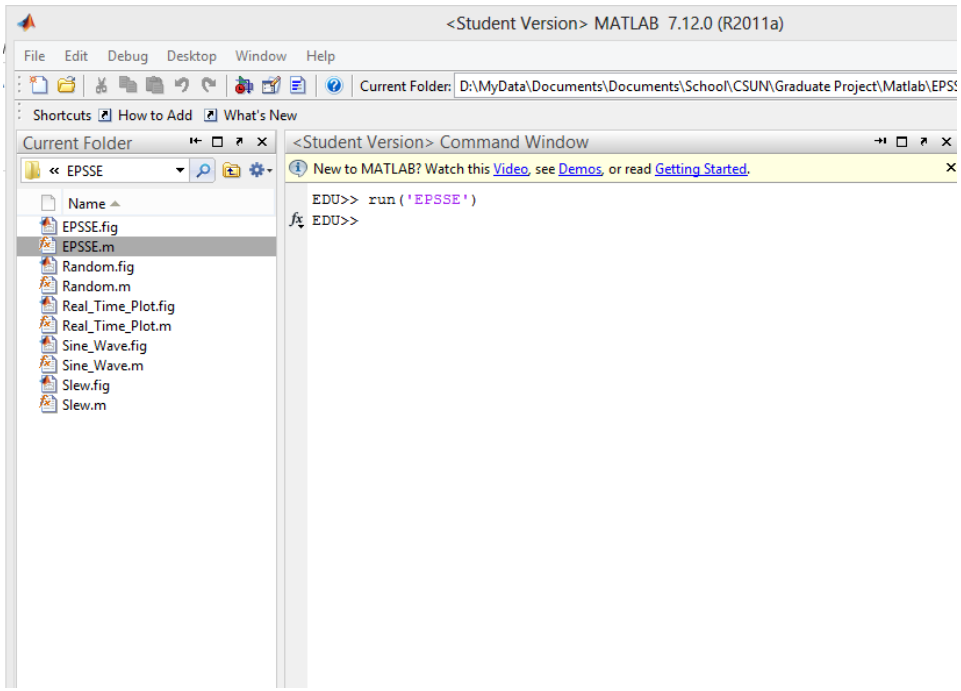
Another method would be to build the data_loader project file and create a batch file, edit that batch file to run the flashcmds.txt, by adding FM @"correct path". Then in the start function edit it so that bat is that file and location. It will save much more time to initially set up the createBatchFile, and therefore a quick hit of the run simulation button will run the test for the user.

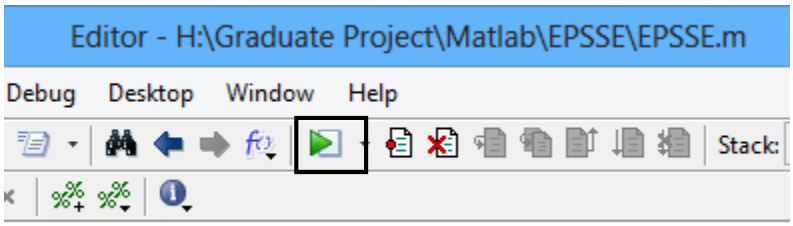
```
%--------------------------------------------------------------------------
% starts the download of the program to the uP
function start()
loc = findDir();
loc2 = sprintf('%sGraduate Project\\Data Loader\\Project Files',loc);
bat = sprintf('%sGraduate Project\\Data Loader\\Project Files\\Target_3.0.bat',loc)
cd (loc2);
%bat = sprintf('E:\\Graduate Project\\Data Loader\\Project Files\\Target1.bat');
s = dos(bat);
if(s == 0)
    msgbox(sprintf('Download Successful Program is Running!'))
else
    msgbox(sprintf('Download Unsuccessful'))
end
cd (loc);
%--------------------------------------------------------------------------
```

10.3.4 Software Configuration

1. Open MATLAB on the Host Computer.

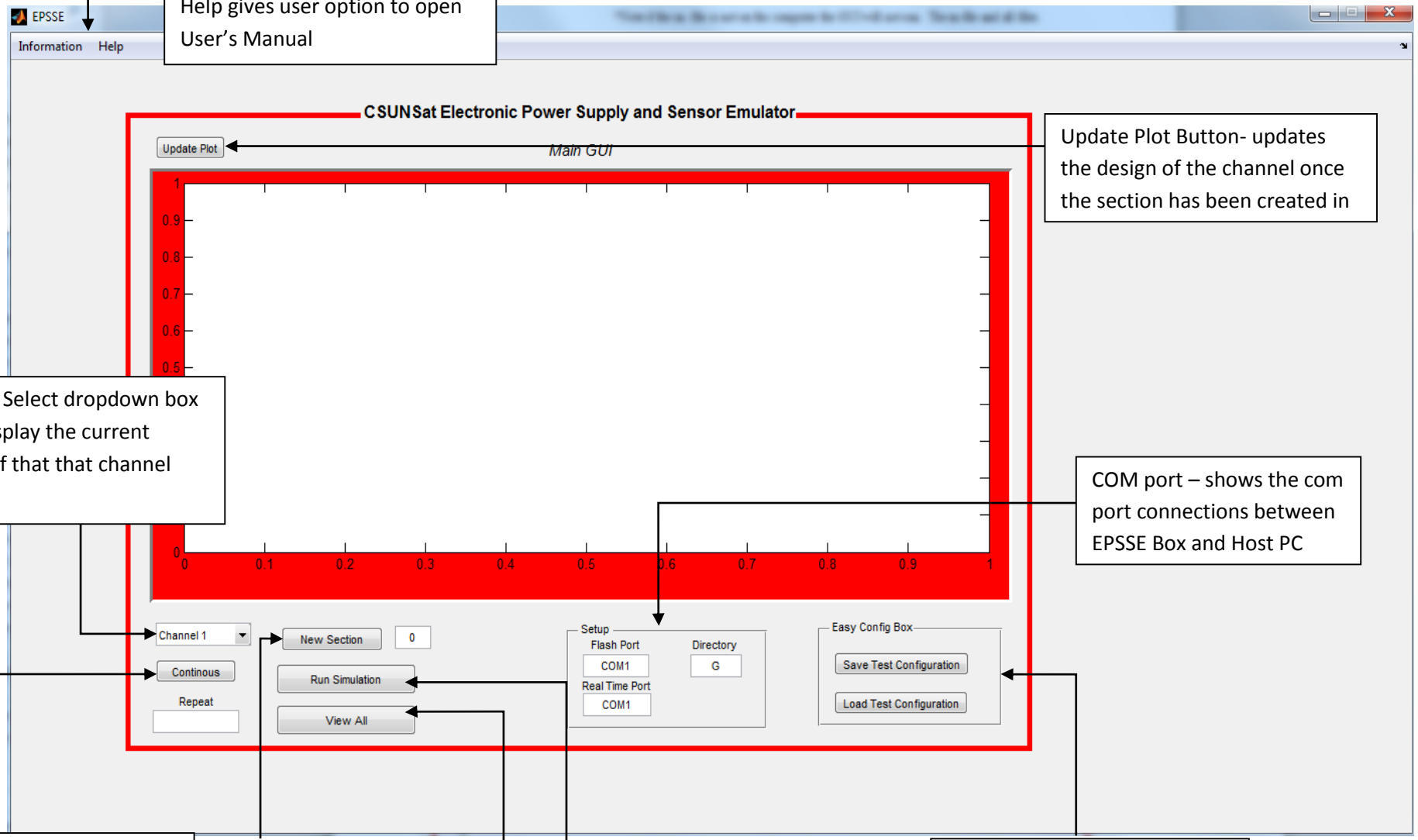
2. Open the EPSSE GUI, by entering run('EPSSE') in the command line in the MATLAB command window. This can also be done by opening the EPSSE m file and clicking on the run button





*Note if the m- file is not on the computer the GUI will not run. The m-file and all files associated with the system should be located somewhere on the Host Computer or you have the flash drive with the file.

Information and Help – Information will give software designer and Revision Info. Help gives user option to open User's Manual



Update Plot Button- updates the design of the channel once the section has been created in

Channel Select dropdown box – will display the current design of that that channel

COM port – shows the com port connections between EPSSE Box and Host PC

Continuous, and Total test section- If continuous is selected the test will continuously run, if not the test will run for a number of durations set in the box

New Section Button- starts a new section in the design

Run Simulation Button-runs the simulation once all the channels are configured

Save and Load Configuration buttons- saves the current configuration or loads a previously save configuration

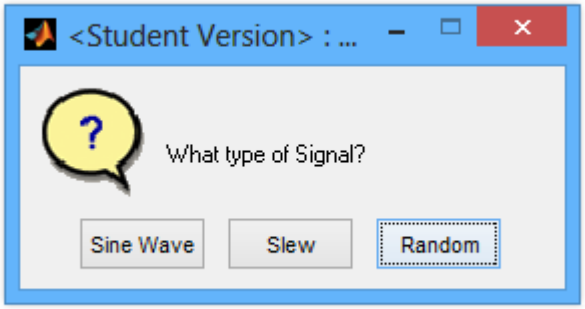
View All Button- will produce a subplot of all of the channels

3. The MATLAB GUI shown above should open. The COM Port box in the upper right hand corner will indicate which com ports the flash port and the real time port are connected to.

From the Main GUI the user can view each channel one by one by flipping through the channel select dropdown box.

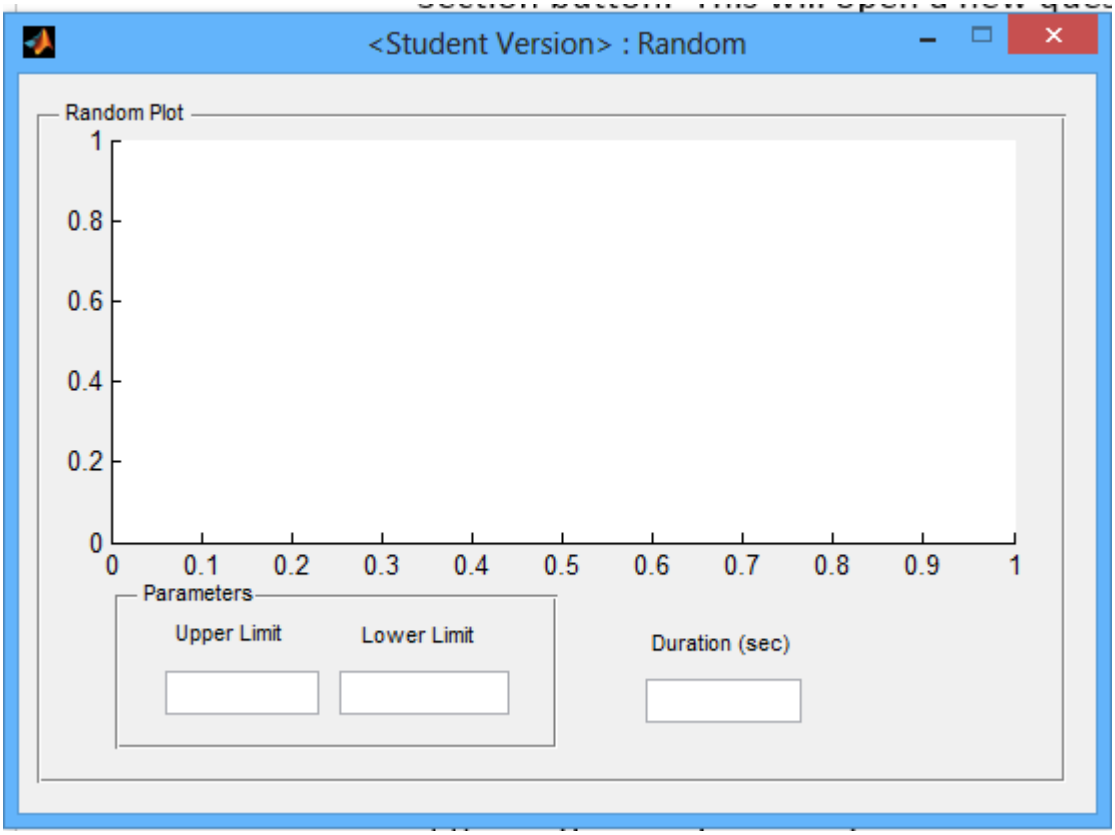
To configure a simulation the first thing to decide is which channel to configure. For example if the user has connected channel 1 to a port on the CubeSat main processor, then channel 1 can be configured by the following steps.

4. To start the design of the test, select the New Section button. This will open a new question box, which will prompt the user to select a type signal.



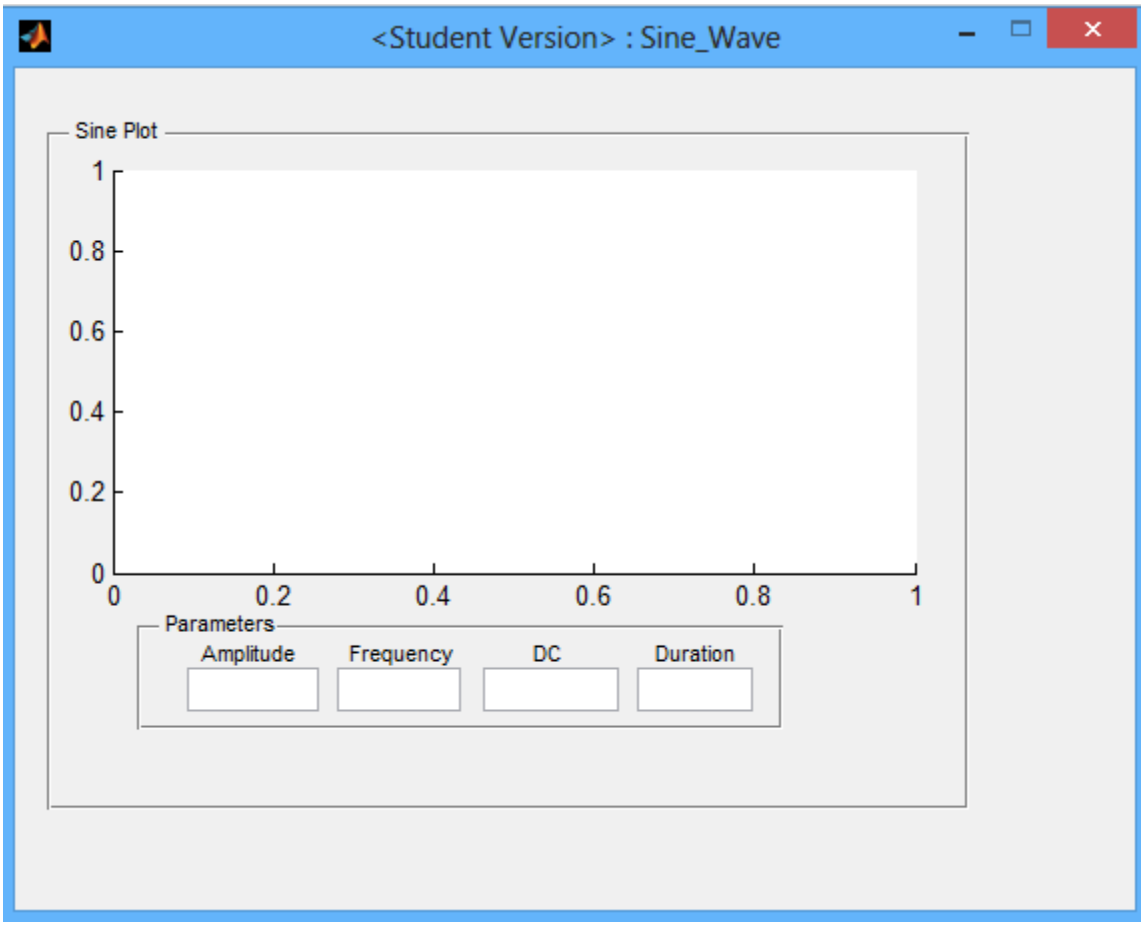
5. Depending on the selection a new GUI will open, all of the GUI's have similarities, a plot, but differ in the input parameters.

*Note: All signals are digital and thus produce a digital signal at a rate of one value per millisecond. All signal parameters are initially set to 0. All signals must be set between 0 and 5.30 to comply with the Vref supplied to the DAC. If any of the signals are set outside this area an error message will appear and the signal will not be plotted or created.

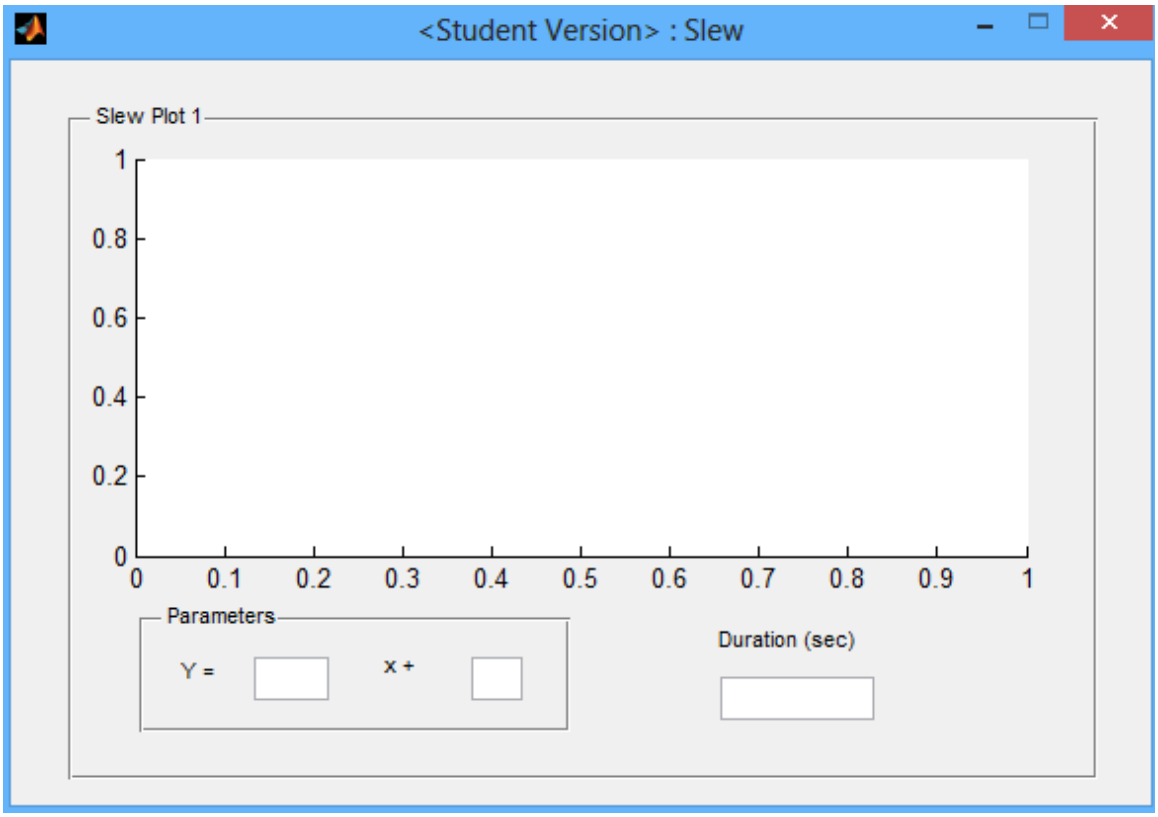


6. Next choose the parameters for the signal.

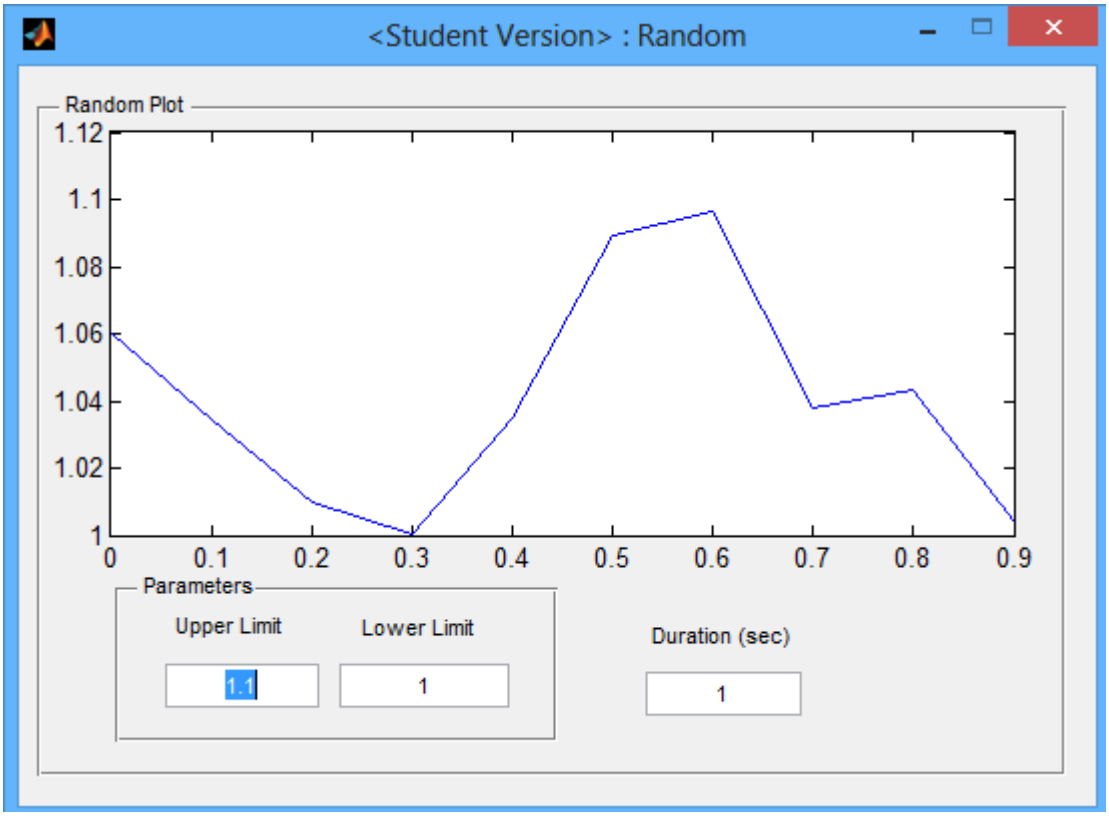
a) for the Random Plot the Upper Limit and Lower Limit will set the upper and lower bounds of randomness, the Duration will as in all of the plots set the duration of this section. The randomness is a Gaussian random value between the upper and lower limit.



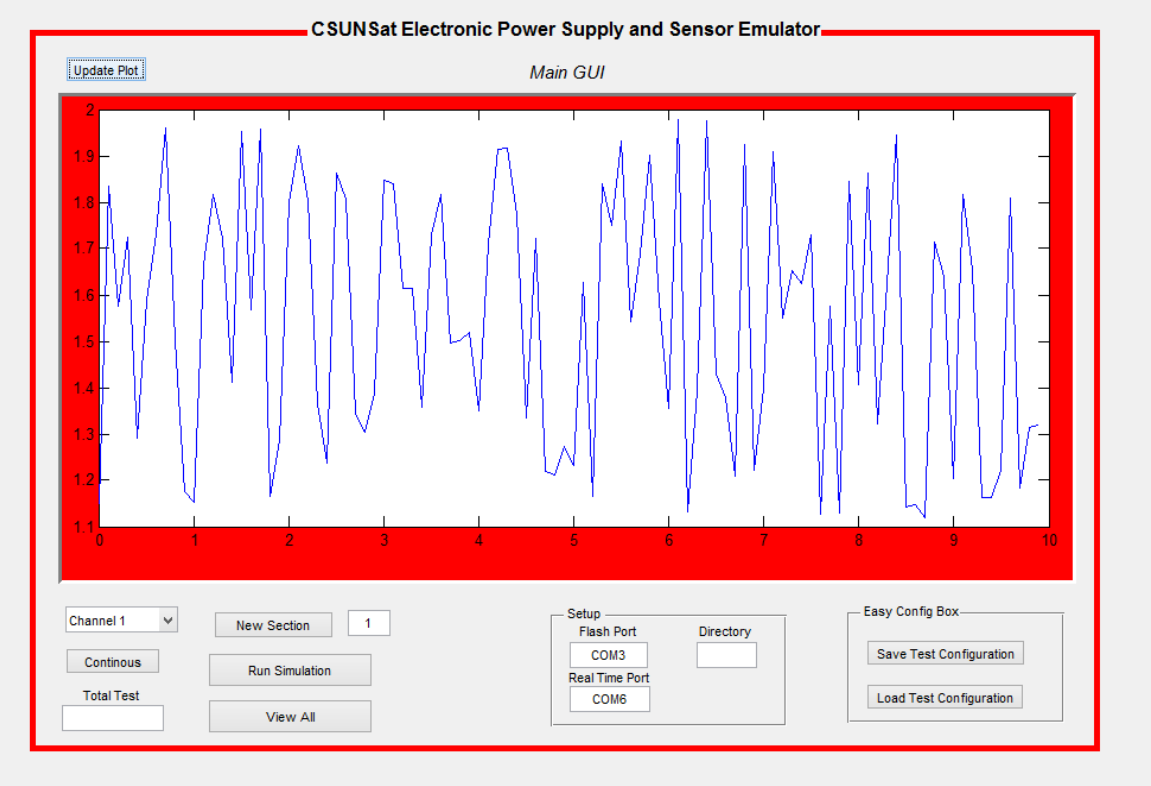
b) the sine wave GUI provides inputs for amplitude, frequency, DC level and duration. The equation is set as Amplitude*sin(2*pi*frequency) + DC level.



c) the slew plot equation is mx+b.

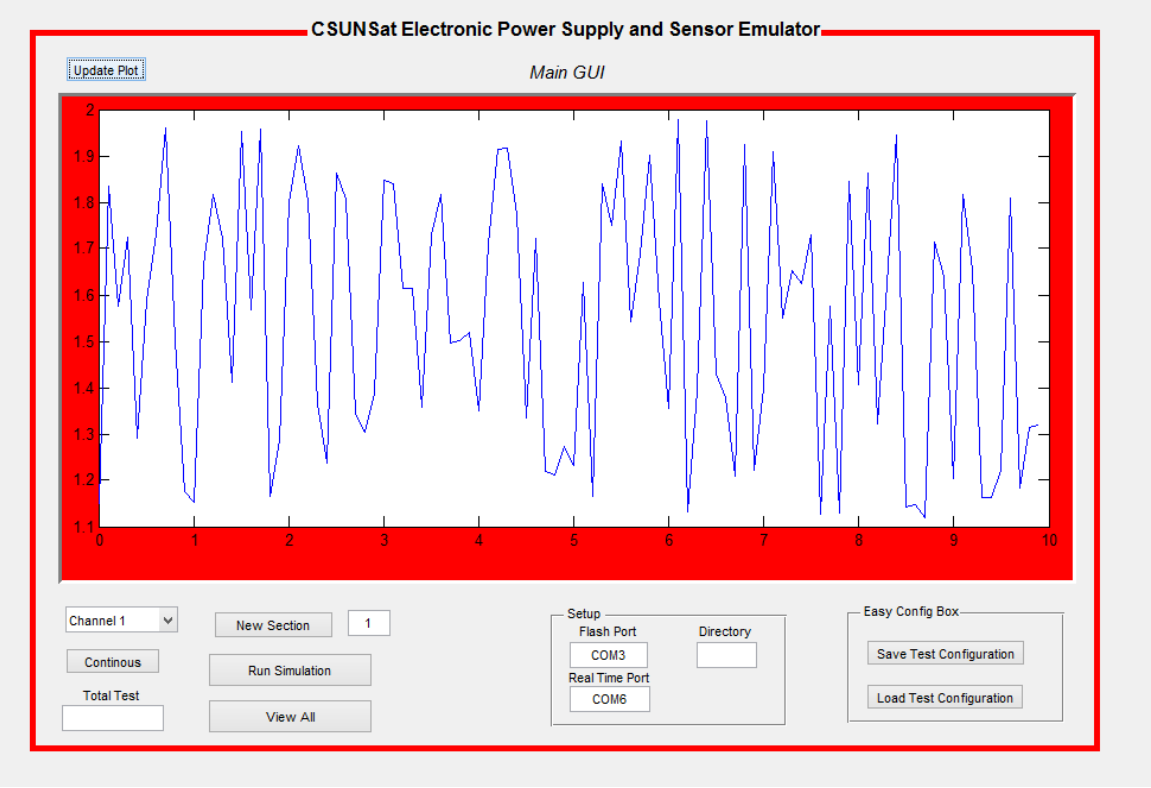


7. This signal is a random signal which has values ranging from 1 to 1.1 for a duration of 1 second.
8. Once the signal is created the user can update the main GUI plot by selecting the update plot button. As can be seen the plot is now updated with the signal. To add another signal stay on the same channel and select the New Section button again. A new question box will appear again and the user can select the type of signal desired. Now repeat the step 6, and choose the parameters for this signal. Each time a new section is selected that section will be concatenated onto the previous. There is no limit to the amount of new sections. This allows the user the ability to configure many combinations a specific signal profiles as desired.

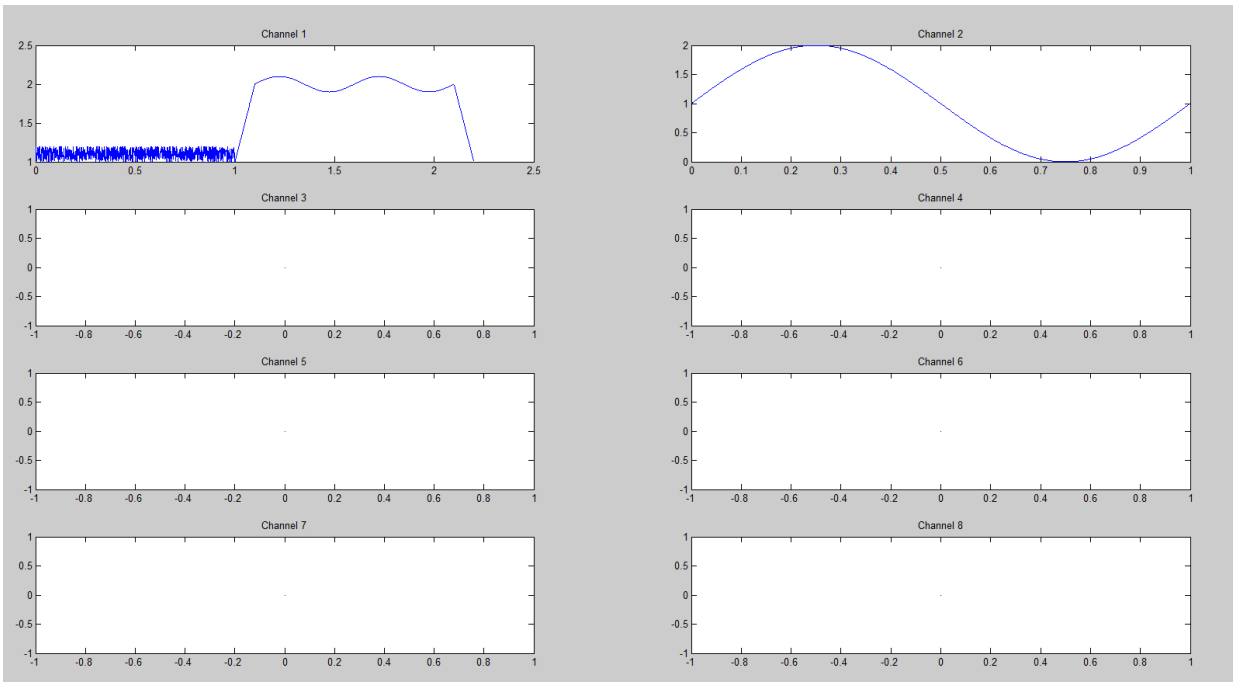


Notice the New Section edit text box has now incremented. This will indicate how many signal sections are in work for this channel.

9. Once all of the sections are finished the next channel can be set up. This is done by selecting the Channel in the Channel Select drop down box.

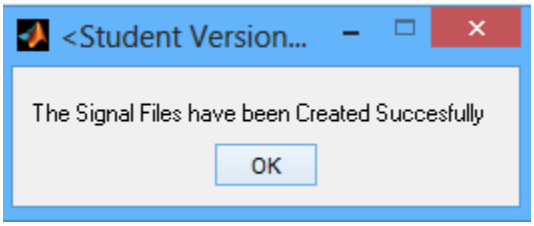


Notice the New Section box has been reset to 0. If for any reason you need to look at any of the channel profiles, simply select it from the dropdown menu, and the signal will be displayed on the Main GUI plot again. Also if at any time the user would like to view all of the signals then select the View All push button.



Each channel will be shown as above. The user can explode a subplot to take up the whole screen by holding down the number on the keyboard. Once the number key is released the view all plot will be displayed as it was before.

10. The user can choose to save the test configuration. The configuration should be saved as a .dat file, which can be stored in the user's desired location. If the user has previously saved a configuration then the load configuration button will allow the user to load the .dat file.
11. Once all of the channels have been configured, then the user should decide if the test will run for a set duration of time, or if the test should run continuously. This is done simply by selecting the continuous push button.
12. If the continuous push button is not selected, then the test will run for the duration of the longest signal profile. In the repeat box the user can set the amount of times to repeat.
13. The real time plot radio button will give the user the option to run a real time plot of the signals as they are being sent out of the EPSSE box.
14. Once all of the test configurations are finished, to start the test select the Run Simulation button, and the test should begin. A pop up box should appear indicating all of the files have been created successfully and that the program is now running. The real time plot will appear on the screen if the user selected the real time plot radio button.


<Student Version...
The Signal Files have been Created Succesfully
OK